Popular Astronomy.

Vol. XXVII, No. 7 AUGUST-SEPTEMBER, 1919. Whole No. 267.

THE SELECTION OF SITES FOR ASTRONOMICAL OBSERVATORIES.

WILLIAM H. PICKERING.

It has been the writer's good fortune to investigate the quality of the seeing in various portions of the earth's surface, especially in the western hemisphere. Trusting that the information that he has gathered by actual experience, as well as by correspondence, may be of use to others, he would epitomize it briefly as follows:—The seeing around the shores of the Mediterranean as well as that around the Caribbean appears to be good during most of the year. It is good at certain seasons in Arizona, southern California, southern Peru, and Ceylon. Southern India, southern Africa, and southern Australia are indifferent, but perhaps as good as northern Europe and the northeastern United States. Evidence so far obtained from the Philippines and Hawaii is unfavorable, but it is thought that this may be due to local rather than general causes, or to other circumstances. For Peru in the southern hemisphere as well as for most, if not all, stations north of the equator, January and February appear to be unfavorable months. As a general rule good seeing is associated with the tropics and neighboring regions, and with remoteness from regions affected by anticyclones.

Five observatories have been located so far with especial attention to the question of securing good seeing. The Lick Observatory, altitude 4000 feet, opened in 1888, was the first observatory ever erected in an unusual location for this particular purpose. Whether the improvement actually secured over a station placed nearer sea level was worth the added inconvenience and expense can be judged better by the observers than by myself. The Arequipa station of the Harvard Observatory, erected in the Andes in 1891, at an altitude of 8000 feet, was especially located in order to secure good seeing. Excellent seeing

was certainly obtained at certain seasons of the year, but this qualification of the site has not been taken advantage of since 1893. The prevalence of cloud during the summer months makes it certain that for the class of work that is now actually done there, a sea-level station in a comparatively cloudless region farther to the south would be far preferable. The third observatory located in an unusual and rather inaccessible region was the Lowell Observatory at Flagstaff, Arizona, altitude 7000 feet, opened in 1894. Very good seeing is secured at this observatory during a considerable part of the year.

Astronomical observational work may be divided into three general classes: that pertaining to the solar system, that pertaining to the sidereal, and that pertaining to the system of the spiral nebulae, lying still farther out in space. The first is the only class absolutely requiring the very best seeing. For double star work moderately good seeing is desirable, but a large aperture is of far more importance. For a study of the nebulae any reasonably good seeing will serve, but an aperture of the largest size is indispensable. In the work of the Lowell Observatory hitherto the study of the first class of objects has predominated. The Solar Observatory located on Mt. Wilson near Pasadena, altitude 6000 feet, is the fourth station situated at a considerable elevation. The writer is not aware of any tests having been made to show whether great altitude is of material advantage in solar work. Little has been done there on the other bodies of the solar system.

The fifth observatory site selected on account of the seeing is that of the Jamaica station of Harvard Observatory, altitude 2000 feet. The seeing here is excellent except during the winter months, when northly winds sometimes prevail, but even then it is much better than at most northern stations. The main work of this observatory since its foundation in 1912 has been such as to require the very best seeing attainable. This class of work was especially provided for by Mr. Boyden in his bequest to the observatory. The station is located in latitude 18° north, and as a result, only 1/40 of the total area of the sky fails to rise above our horizon, and only 1/25 fails to reach an altitude of 5°.

These facts are important, since such is the clearness of the tropical skies, that comparatively faint stars are often seen near the horizon. Thus the double γ Volantis, equivalent magnitude 3.7, is frequently visible to the naked eye, although its declination is $-70°.3$, so that it never rises more than 1° 40′, or 1° 54′ allowing for refraction, above our theoretical horizon. The accompanying photograph, which has been enlarged, was taken by moonlight with a short-focused quick acting lens, such as is used for taking moving pictures. The aperture as seen from the center of the field measures ¾ inch (20mm) and the focus is 3 inches (72 mm). The view was taken on the night of December 27,

1917, at $15^h\ 45^m$ E. S. T., with an exposure of 5 minutes. The moon was in a state of partial eclipse, the shadow just reaching the center of the disk. Under these circumstances it gives appreciably less light than when it is on the quarter, and about as much as the sun gives in this latitude, one hour before sunrise.

The two bright stars, appearing as short lines, on the extreme left of the picture are α and δ of the Southern Cross. The former is the finest triple in the sky, and forms the bottom of the cross. The two bright stars very close together which have passed the meridian and are on the right of the picture are a and ι Carinae. They form the following arm of the False Cross, the other stars being κ and δ Velorum, shown above and farther to the right, and ϵ Carinae still farther to the right and below, but not shown. This is a configuration well known to dwellers in the tropics, but unknown officially to astronomers. It resembles the true cross, but is rather larger and fainter, and is sometimes mistaken for it. The varying directions of the star trails indicate that the position of the south celestial pole is situated about an inch below the bottom of the picture, a little to the right of the middle. Half way between a and ι Carinae, and δ Crucis is the great naked eye nebula η Carinae, containing the remarkable variable star of the same name, and 0.4 inch north following it is a somewhat smaller very faint hazy object, N. G. C. 3532, the finest irregular cluster in the heavens, north or south. Below η is the little group of stars surrounding θ Carinae. The bright star preceding θ is υ, and below and preceding that, just above the horizon to the right of the palm tree, is β Carinae, declination $-69°.3$, magnitude 1.8. This star rises $2°.7$ above our theoretical horizon, and about one degree above the actual one. The photograph illustrates the fact that even for the actinic rays the earth's atmosphere is quite transparent, when free from dust and other impurities.

There is a general impression among astronomers that in order to secure the best seeing we should go to a dry climate. Indeed the sites of a number of observatories have been selected in the last thirty years with this idea in mind. This view is quite erroneous. In order to put the matter to a test however, we measured the dew-fall here on fifteen nights when the seeing was unusually bad, 3 and 4 on the standard scale. We also measured it on thirteen nights when the seeing was perfect as far as we could judge with our 11-inch aperture, namely 12 on the standard scale. On the nights of poor seeing the average dew-fall was 3.6 cubic centimeters per square meter. On the nights of good seeing it was 108.1 cubic centimeters, or just thirty times as much. Instead therefore of finding good seeing associated with a dry atmosphere, we find that precisely the reverse is the case.

Mandeville, Jamaica, B. W. I.
April 21, 1919.

THE CHANGING OF THE DATE AT THE 180th MERIDIAN.

ALBERT S. FLINT.

This is a question which arises in connection with trans-Pacific voyages and one which in many cases, the writer suspects, receives no ready reply that seems real and satisfactory to the average mind. The puzzle possesses its most popular interest, perhaps, when the experience is related by which a ship proceeding in one direction has in its calendar one week of eight days including two successive days as Sunday, while another ship proceeding in the opposite direction has in its calendar one week of six days only and with no Sunday at all. Yet the average person understands why countries to the eastward of England have a later time than that of England for any given event an earthquake in Italy, for example, while those to the westward have an earlier time for the same event. A little further thought only is required to realize the necessity of the change in date made at the 180th meridian.

There appear to be four types of explanation found in the books on elementary astronomy as to this changing of the date. Upon examining such of these books as the writer found at hand, sixteen in number, each of these types of explanation was found in one or two of them, while in eight of the books there was no mention of the matter.

One explanation asks the reader to imagine himself to start at noon on the Greenwich meridian with the sun directly overhead and travel westward, keeping the sun overhead, until he has completed the circuit of the earth and returned to his starting point. Experiencing no change in the aspect of the day as presented to him, he is supposed to call it noon of the same date clear around the world, although upon his return he finds his date is one day behind that of his former associates.

The second explanation allows the traveler to make the circuit of the globe at his own convenience, but brings in the principle of added or subtracted apparent revolutions of the sun about the earth, due to the complete rotation made by the person himself about the axis of the earth in the course of his journey. If he goes around the world to the eastward he experiences one apparent revolution of the sun in addition to the actual number and seems to gain one day; while if he goes westward he experiences one less apparent revolution of the sun and seems to lose one day.

There appear to be two objections to the former of these explanations. First, it is unreal. Nobody can travel around the world with the sun; and it does not appear to the ordinary reader, why such a fancy should produce so important a change to the traveler. Again, this explanation touches only one phase of the case, that of traveling westward, and has no word for the opposite phase, that of traveling eastward.

The objection to the second explanation is that it is not expressed in popular concepts, so as to be understood readily by persons lacking in geometrical training.

The third explanation has the advantage of starting with a common experience—or, if one has not had the experience, he may read of it in books of travel. Many people are familiar with change of time on railroad journeys eastward or westward. For example, they know that a watch which was correct upon leaving New York will be one hour fast upon arrival at Chicago. Correspondingly, when a ship leaves New York to cross the Atlantic and has proceeded fifteen degrees in longitude, the ship's clock will be one hour slow; that is, when it is noon for the ship's position at sea, sun nearly due south, the clock will read 11 a. m. Hence it is customary to set the clock one hour ahead or one hour back for every fifteen degrees eastward or westward respectively. It follows that if two travelers start from New York, for example, at the same time to go around the world, one to the eastward, the other to the westward, and in due time meet on the other side of the world at the meridian opposite to that of New York, the former's watch will be twelve hours fast of New York time, while the latter's watch will be twelve hours slow of New York time,—a difference of twenty-four hours or one day. But each has kept his time and calendar day in agreement with those of the countries he has visited successively, including those of Singapore, let us say, where they meet. Then one or the other must have made a change in his calendar day. This change, it has been agreed by the leading governments, is to be made at the 180th Greenwich meridian. Hence the west-bound traveler must have dropped out a day from his calendar—jumped one day—which brings his date into agreement with that of the east-bound traveler when they meet. When the east-bound traveler crosses the 180th meridian he too must make a corresponding change. He must repeat —take on—a day in order to agree with the countries to the eastward.

Yet this explanation does not appear quite satisfactory; for it does not bring out in its primary form the convention which controls the matter, nor does it picture to the mind of the reader a single, concrete, view of the conditions which necessitate the change.

The fourth type of explanation rests upon a *statical* view of the question, which seems the better way. This was found in two books of those examined: Professor Herbert A. Howe's excellent "Elements of Descriptive Astronomy" and Professor Harold Jacoby's very interesting "Practical Talks by an Astronomer". Yet both of these explanations are rather brief and abstract, and something more seems desirable for popular presentation. The former of these books cites a Greenwich hour when there are already two different dates in the world, while the latter takes no particular Greenwich hour and merely makes a general statement. In view of the defects noted above I should like to submit under this type the following explanation of the change of date at the 180th meridian. This seems to have an advantage in that it requires only a mental picture which is readily formed.

Suppose the reader to stand before a terrestrial globe with the Greenwich meridian directly before him. Let a lamp directly behind him represent the sun, say, at the time of the equinox, March 21. The position of the globe, as regards its rotation about its axis, corresponds to Greenwich noon. The reader sees the half of the globe towards him in daylight while the opposite half is in the darkness of night. The dark quarter of the globe beyond the western edge is in the morning hours of the night while that beyond the eastern edge is in the evening hours. The convention upon which the governments agreed should properly be stated, in the writer's opinion, as follows:—

At the *instant of Greenwich noon* the calendar date shall be *one and the same* all around the world. And this having been accepted, Greenwich noon is, then, the *only instant* at which the date can be the same all around the world.

If the noon at Greenwich is that of March 21, for example, then the midnight at the 180th meridian is evidently the beginning of March 21 on the east side, as in western Alaska, and the closing of March 21 on the west side as in eastern Siberia. Hence the east-bound traveler, upon crossing the meridian at that instant, must repeat the day March 21, Friday, in his calendar, while the west-bound traveler must omit that date from his calendar and pass on to March 22, Saturday. And it is evident that the traveler must make the change at whatever day and hour he crosses that meridian if he is to keep his calendar in agreement with those of the countries he may visit in the continuation of his journey. Strictly the navigator should make the change at the instant of crossing the meridian; but all counting of time is a convention, to suit the convenience of the people concerned, and so navigators have agreed that when on the open sea they will make the change at the midnight nearest to the time of actual crossing.

To return to the case of Sunday in the calendar week:—if a ship going westward is approaching the 180th meridian near midnight of Saturday, August 2, for example, the navigator enters the new day in his log-book as Monday August 4, thus losing Sunday out of the week, but if the ship is going eastward and is approaching the meridian near midnight of Sunday August 3, for example, he enters the new day also in his log-book as Sunday, August 3, thus repeating the Sunday of that week. This may occur also to any other day of the week, of course.

Thus the calendar of the traveler in making the circuit of the world is kept in agreement with the calendar of any country he may visit, including that of his own home, when he returns to it.

Madison, Wis., April, 1919.

LEAP YEARS WITH FIFTY-THREE SUNDAYS.

CARL BOECKLEN.

In volume XXV of POPULAR ASTRONOMY (January 1917, p. 72) Mr. F. Campbell tried to solve this problem; he did not, however, arrive at a full solution.

In order to find a complete answer to the question, we shall use two of the many devices which the medieval computists invented for the solution of problems connected with the calendar and with chronology. These devices may still be employed to advantage for the solving of problems similar to the present one.

Dominical Letter. Take the seven letters A, B, C . . . . G and put

A against	Jan. 1, 8, 15	Dec.	17, 24, 31
B "	Jan. 2, 9, 16	Dec.	18, 25
.....			
G "	Jan. 7, 14, 21	Dec.	23, 30,

so that every day of the year receives its proper letter. It is obvious that A is to be set against Dec. 31 because the common year of 365 days consists of fifty-two weeks and one day.

Let us use the year 1919 for an example: it began with Wednesday, the first Sunday was January 5 with the letter E. It is evident that all the days with the letter E are the Sundays of the current year, hence E is the dominical letter of 1919.*

* The month of June is the only one of the twelve months, the first day of which bears the letter E, thus one month of the present year will begin with Sunday.

This applies to common years; a certain complication arises in leap year which the old computists overcame in a very simple way. They counted in their computations and cycles the intercalary day (Feb. 24) and the day following (Feb. 25) as a single day according to the rule of the Roman Law: Hoc biduum pro ano die habetur. Thus we have the following arrangement for the end of February.

	Feb.	23	24	25	26	27	28	29	Mar. 1
Common year:		E	F	G	A	B	C	—	D
Leap year:		E	F		G	A	B	C	D

A consequence of this arrangement is that a leap year has a double letter for its dominical letter. The first letter applies to the period from January 1 to February 24, the second (which is always the one preceding the first letter in the alphabetical order) applies to the period from February 25 to January 31. For example: the year 1920 will begin with Thursday and end with Friday, therefore its dominical letter will be DC.

It is now evident that the common years with the dominical letter A which begin and end with Sunday have 53 Sundays; and that the leap years with the dominical letters AG or BA have likewise 53 Sundays. The former begin with Sunday and end with Monday, the latter commence with Saturday and close with Sunday.

The question arises now, how to find the dominical letter of a given year. There are several ways to that end, the most convenient for our purpose is furnished by the "Solar Cycle."

Solar Cycle. The intercalary period is four years, and the number of days of the week is seven; hence after a period of $4 \times 7 = 28$ years the dominical letters will recur in the same order. This period is called "Solar Cycle," and it is assumed that the year —8 (or 9 B. C.) was the first year of a cycle. We have therefore the following rule for finding the solar cycle for a given year of the Christian era. Add 8 to the given year and divide the sum by 28, the remainder raised by one will be the solar cycle of that given year.

For example: $1919 + 8 = 1927$, which divided by 28 leaves as remainder 23; solar cycle of 1919, XXIV. We see from this that a new cycle will begin with the year 1924.

The relation between solar cycle and dominical letter is rigidly fixed in the Julian Calendar, because the quadrennial intercalation is continued without any interruption. Not so in the Gregorian calendar; a change in that relation occurs every time that the intercalation is omitted (as in 1700, 1800, 1900 etc.) This relation is indicated by the following:

Solar Cycle:	I	II	III	.....	XXVII	XXVIII
Julian Calendar:	GF	E	D	.....	B	A
Gregorian Calendar:						
1800-1900	FD	C	B	.....	G	F
1900-2100	FE	D	C	.....	A	G

Each letter occurs five times in such a series of twenty-eight diminical letters, there are three common years with the dominical letter A, one leap year with AG and one leap year with BA. Hence there are in a complete cycle three common years and two leap years with 53 Sundays.

It is now easily determined that in the nineteenth century the years with the solar cycle XXI and IX had the dominical letters AG and BA respectively; and that in the current century the years with the solar cycles V and XXI correspond to those dominical letters. Hence the full list of leap years with 53 Sundays for the two centuries named is:

Dominical letter AG:	1804,	32,	60,	88,	1928,	56,	84		
" " BA:	1820,	48,	76		1916,	44,	72,	2000	

Finally it may be added that in 400 Gregorian years there are 43 common years and 28 leap years with 53 Sundays, and that these years recur in the same order after 400 years.

Another remark: February 1 has the letter D and the last day of that month the letter C. It is therefore evident that February has five Sundays in the leap years with the dominical letter DC. This occurred in 1880 and will occur again in 1920. There are 13 such leap years in 400 Gregorian years, after the end of which period those leap years will recur in the same order.

THE FLASH SPECTRUM OF JUNE 8, 1918.

H. C. WILSON.

[*Continued from page 373.*]

TABLE I—Continued.

Exposure I Chromosphere		Exposure II Flash		Mitchell 1905		Rowland Lines in Sun		Substance
Intensity	Wave-Length	Intensity	Wave-Length	Intensity	Wave-Length	Intensity	Wave-Length	
				2	4518.20	3	4518.198	Ti
				3	.47	1	.506	
		2	4518.46					
2	4520.46	*c* 5	4520.37	8	4520.38	3	4520.397	Fe?,-
1	4521.01			1	4521.35	0	4521.304	Cr
3	4522.85	*c* 6	4522.86	12	4522.83	3	4522.802	Fe
						2	.974	Ti

TABLE I—Continued.

Exposure I Chromosphere		Exposure II Flash		Mitchell 1905		Rowland Lines in Sun		Substance
Intensity	Wave-Length	Intensity	Wave-Length	Intensity	Wave-Length	Intensity	Wave-Length	
		0	4524.27	1	4524.05			
		1*d*?	4525.31	3	4525.31	5	4525.314	Fe
				1	4526.26	0	4526.269	Cr
						1	.579	
		1	4526.58			2	.632	Cr
						1	.732	Fe
		1	4527.49	3	4527.49	3	4527.490	Ti
		c 2	4528.83	5	4528.76	8	4528.798	Fe
						1	4529.656	
		1	4529.86	4*d*	4529.71	1	.728	
						1	.849	Fe
		2*d*?	4531.21	1	4531.08	2	4531.123	Fe?,Co
				3	4531.33	5	.327	Fe
		0	4532.02	1	4531.80	2	4531.801	Fe
				2*d*	4533.34	4	4533.419	Ti
5	4534.19	*c* 8	4533.97	15	4534.20	6	4534.139	Ti-Co
				2	4534.89	4	.953	Ti
				3	4535.74	3	4535.741	Ti
		4*d*	4535.87			1	.879	Cr
						2	4536.094	Ti
				3	4536.15	2	.222	Ti
		0	4537.94	1*N*	4538.00	0	4537.845	
		0	4539.21	0*N*	4539.17			
		1	4539.98	3	4539.96	0*N*	4539.946	Cr
		0	4540.73	2	4540.77	2	4540.672	Cr
						2	.880	Cr
		2*d*	4541.66	4*d*	4541.66	2	4541.690	Cr
		1	4544.19	2*d*	4544.11	1	4544.190	
				2	.84	3	.864	Ti
		2	4545.20	2	4545.28	1	4545.311	
						0	.507	Cr-V
		1	4546.10	2	4546.12	3	4546.129	Fe, Cr
		0	4547.18	2	4547.20	2	4547.192	Fe
0	4548.21	0*r*	4548.13	2	4548.02	3	4548.024	Fe
5	4549.84	*c* 8	4549.71	20	4549.80	2	4549.642	Fe
						6*d*?	.808	Ti-Co
		1	4552.17					Short
						2	4552.632	Ti
		1	4552.59	3*N*	4552.63	1	.725	Fe
0	4552.92	0	4553.01	0	4553.16			
6	4554.26	*c* 7	4554.19	20	4554.28	8	4554.211	Ba
				2	4555.69	3	4555.662	Ti
2*d*	4556.11	*c* 5	4556.02	10	4556.06	3	4656.063	
						4	.306	Fe-Cr
0	4557.39			0	4557.46	0*N*	4557.457	
2	4558.88	*c* 4*d*?	4558.74	8*d*	4558.74	3	4558.827	Cr?
		1	4560.30	1	4560.26	2	4560.266	Fe
				2	4560.50			
		0	4560.94	0	4560.87			
		1	4562.61	4	4562.47	0	4562.541	

TABLE I—Continued.

Exposure I Chromosphere		Exposure II Flash		Mitchell 1905		Rowland Lines in Sun		Substance
Intensity	Wave-Length	Intensity	Wave-Length	Intensity	Wave-Length	Intensity	Wave-Length	
4	4563.99	*c* 5	4563.77	15	4563.93	4	4563.939	Ti
						00	4564.750	
		1	4564.81	1	4564.79	0	.875	
				2	4565.67	3	4565.688	Cr
		* 2	4565.86	1	.88	2	.842	Co-Fe
				0	4566.38	00*N*	4566.414	
		1	4566.68			1	.693	Fe
				0	.96	1	4567.046	Fe
		0	4568.15	1	4568.36			
						0	4568.499	
		1	4568.89	1	4568.88	1	4568.940	Fe
		† 2	4571.25	3	4571.25	5	4571.275	Mg
5	4572.22	*c* 9	4572.14	20	4572.17	6	4572.156	Ti-
		1	4574.56	0	4574.05	1	4574.396	Fe
		0	4575.10	1	4574.91	2	4574.899	Fe
		0	4575.63					
1	4576.50	2*d*?	4576.53	4	4576.49	2	4576.512	Fe
				0	4578.71	3	4578.732	Ca
		1	4579.02	1	.97			
0	4580.03	2*d*	4580.28	3	4580.12	3	4580.228	Cr
		‡ 1	4581.61	3	4581.59	4	4581.575	Ca
						4	.693	Co, Fe
				0	4582.38	0*N*	4582.483	
¶ 1	4583.02	1	4583.05	2*d*	4582.84	1	4583.011	
4	4584.07	*c* 7	4583.98	15	4584.04	4	4584.018	Fe-
		0	4585.56	0	4585.45	0	4585.519	
		0	4586.17	2	4586.08	4	4586.047	Ca
				2	.48	1	.408	Cr
						1	.552	V
		0	4587.21	1	4587.28	2	4587.308	Fe
2*d*	4588.46	2	4588.45	5	4588.37	3	4588.381	Cr
		1	4589.44					
2	4590.15	*c* 3	4590.13	6	4590.10	3	4590.126	Fe
		1*d*	4591.56	2	4591.56	2	4591.574	Cr
						1	.693	
0	4592.23	1	4592.26	2	4592.09	1	4592.231	Cr-
						2	4592.707	Ni
		2*d*	4592.79	3	4592.70	4	.840	Fe
		1	4593.79	1	4593.70	1	4593.704	
		1	4594.49	3*d*	4594.16	2*N*	4594.297	V
				0	.80			
		0	4595.46	2	4595.45	2	4595.540	Fe
		0	4596.13	1*N*	4596.04	0	4596.128	Ni
						2	.245	Fe

* Ragged.
† At edge of next.
‡ Faint narrow line between.
¶ Close to edge of next.

TABLE I—Continued.

Exposure I Chromosphere		Exposure II Flash		Mitchell 1905		Rowland Lines in Sun		Substance	
Intensity	Wave-Length	Intensity	Wave-Length	Intensity	Wave-Length	Intensity	Wave-Length		
		0	4597.07	1*d*	4597.15	0*N*	4597.080	Co	
		0*d*	4598.33	1	4598.31	3	4598.303	Fe	
						2	4600.018	Fe?	
		1	4600.26	1	4600.34	1	.279	Cr	
						2	.541	Ni	
		2	4600.96	2	4600.91	3	4600.932	Cr	
				1	4601.33	0	4601.207	Cr	
		1	4602.27	2	4602.20	3	4602.183	Fe	
		* 2	4603.19	3	4603.12	6	4603.126	Fe	
		† 0	4604.54	0	4604.70	2	4604.735	Fe?	
						0	4611.368	Cr	
		2*d*?	4611.54	3	4611.46	5	.469	Fe	
		3*t*?	4613.44	4	4613.50	3	4613.386	Fe	
						3	.544	Cr, La	
		1	4614.83	1	4614.58				Ragged
		0	4615.58	2	4615.74	1	4615.743	Fe?	"
		3	4616.22	3	4616.26	4	4616.305	Cr	"
		1	4616.97	1	4616.80	1*N*	4616.804		"
				2	4617.47	3	4617.452	Ti	
		0	4617.70						
2	4618.97	3*t*?	4619.05	4	4618.98	4*d*?	4618.971	Fe	
		1	4619.52	2	4619.47	3	4619.468	Fe	
				0	4619.98	1	4619.711	Cr	
		3*t*?	4620.66	4	4620.72	1	4620.693	Fe	
		1*d*	4622.09	2*d*	4622.08	0	4622.065	Cr	Hazy
						1	.128	Cr	
		1*d*	4623.25	3	4623.27	2	4623.279	Ti	
		1	4625.18	2	4625.20	5	4625.227	Fe	Lumpy
		1	4626.23	3	4626.39	5	4626.358	Cr	
		2	4626.64	0	.78	0	.718	Mn	
						0	4627.547		
		1	4627.28	1*d*	4627.61	0	.726		
0	4628.24			3	4628.42	0	4628.335		
4	4629.55	*c* 7	4629.41	12	4629.63	6	4629.521	Ti-Co	
		1	4630.26	1	4630.32	4	4630.306	Fe	
		0	4631.27			0*N*	4631.212		
		0	4632.23	0	4632.36	0	4632.320	Cr	
				3	4632.99	1	4632.991		
		‡ 1	4633.18			4	4633.100	Fe	
				0	4633.43	0	.432	Cr	
		¶ 1	4633.94	0	4633.94	0*N*	4633.950		
1	4634.19	1	4634.26	3	4634.21	2	4634.254	Cr	
		¶1	4635.94	0	4636.00	2	4636.027	Fe	

* In hazy band.

† At edge of band.

‡ Perfectly straight.

¶ Crooked; perhaps fragments of two lines.

‖ Ragged.

TABLE I—Continued.

Exposure I Chromosphere		Exposure II Flash		Mitchell 1905		Rowland Lines in Sun		Substance	
Intensity	Wave-Length	Intensity	Wave-Length	Intensity	Wave-Length	Intensity	Wave-Length		
		* 1	4637.76	1	4637.66	5	4637.685	Fe	
		1	4638.17	2	4638.19	4	4638.193	Fe	
						2	4639.538	Ti	
		2*t*?	4639.99	2	4639.69	2	.846	Ti	
				2*d*	4640.34	1	4640.119	Ti	
						1	.468	Ti	
		† 1	4642.53	2	4642.48				
		0	4643.59	2	4643.58	4	4643.645	Fe	
		0	4644.32	1*N*	4644.36				
		0	4645.10	1	4645.48	0	4645.368	Ti	
		c 3	4646.29	5	4646.33	5	4646.347	Cr	
		1	4647.54	2	4647.63	4	4647.617	Fe	
		1	4648.84	2*d*	4649.03	4	4648.835	Ni	
		1	4651.27	2	4651.46	4	4651.461	Cr	
1	4652.29	*c* 2	4652.29	3	4652.33	5	4652.343	Cr	
		1	4654.10	0	4654.28	0	4654.327		
						4	.672	Fe	Ragged
		c 3	4654.86	3*d*	4654.81	5	.800	Fe	
		1	4655.70	1*N*	4655.90	0	4655.832	Fe	
						0	.967	Ti	
0	4656.60	1	4656.58	1	4656.61	3	4656.644	Ti	
1	4657.58	2	4657.30	3*d*	4657.27	2	4657.380	Ti?	
		1	4658.80						Crooked
		1	4660.12	0*d*?	4660.36				
		0	4661.04			0	4661.083		
		1	4662.31	0	4662.14	1	4662.149	Fe?	
		1	4663.43	1	4663.52	1	4663.492	Cr	
		1	4663.86	2	4663.99	0	.882		
						1	.999	Cr	
		1	4664.62	0	4664.51				
				0	4665.00	3	4664.965	Cr	
1	4666.74	1	4666.36	1*d*	4666.26	1	4666.076	Cr	
						0	.387	Cr	
		‡ *c*				1	.655	Cr	
				3*N*	4666.91	1	.925		
0	4667.40	4	4667.22			1	4667.159	Ni	
						4	4667.626	Fe	
		3	4667.84	3	4667.79	3	.768	Ti	
						1	.941	Ni	
						4	4668.331	Fe	
		1	4669.43	2*d*	4669.62	3	4669.354	Fe	
						1	.504	Cr	
		2	4670.08						
1	4670.42					1	4670.346	Ni	
		2	4670.68	4	4670.55	2	.590		
1	4671.05								

* Parts of two lines.

† Fragmentary.

‡ Set on maxima in band.

TABLE I.—Continued

Exposure I Chromosphere		Exposure II Flash		Mitchell 1905		Rowland Lines in Sun		Substance
Intensity	Wave-Length	Intensity	Wave-Length	Intensity	Wave-Length	Intensity	Wave-Length	
		0*r*	4671.79	0	4671.57	1	4671.601	
						0	.858	Mn
		1	4672.51	1	4672.51	3*N*	4672.509	
		1	4673.41	2	4673.32	4	4673.347	Fe
0	4673.91	0*r*	4673.96	0	4674.30	1*N*	4674.275	Too narrow
		1	4674.64	1	4674.82	0*N*	4674.829	
		1	4675.31			1*N*	4675.294	Ti
		1	4678.47			3*N*	4678.347	Cd
		2	4679.18	2*N*	4679.19	6	4679.027	Fe
						2*N*	.409	
0	4680.20	2	4680.29	1	4680.31	1	4680.317	Zn
						1	.480	
0	4680.92	2	4680.71	1	4680.89	1	.658	Cr
						0	.745	
						0	4681.037	Cr
0	4681.86	2	4682.00	2	4682.12	3	4682.088	Ti
						1	.295	Fe?
0	4682.37	2	4682.39	2	4682.58	1	.529	-Co
0	4683.19							
6	4685.82			1*N*	4686.00	...	(4685.98)	He
		1	4691.43			1	4691.523	Ti
				3	4691.69	5	.602	Fe
		1	4691.73			1*N*	.777	
		0	4692.75	0	4692.75	0*N*	4692.829	
						0	4698.579	Co
*		1	4698.38	0	4698.33	1	.641	Cr
						1	.798	Cr
		2*d*?	4698.78	3*d*	4698.83	1	.946	Ti
		0	4699.58	1	4699.52	4	4699.511	
				0	4700.33	4	4700.337	
		1	4700.67			0	.795	Cr
				0	4701.26	1	4701.231	Fe?
		1	4701.60			1	.535	
				0	4701.69	1	.714	Ni
						0*N*	4702.083	
		0	4702.40	0	4702.11	0	.473	
1	4603.19	5*d*	4703.29	3	4703.16	10	4703.177	Mg
				1	4703.93	3	4703.994	Ni
		† 0	4704.36	0*N*	4704.53	00*N*	4704.365	
						0	.658	
		0	4705.14	1	4705.10	4	4705.131	Fe
		0	4705.56			0	4705.641	Fe?
		1	4706.59	1	4706.69	0	4706.730	V
		1	4707.60	2	4707.48	5*d*?	4707.457	-Fe
						2	.672	
		2*d*	4708.96	2	4708.80	2	4708.846	
				1	4709.10	1	4709.153	Ti
						3	.271	Fe

* At edge of next.
† Hazy line between.

TABLE I—Continued.

Exposure I Chromosphere		Exposure II Flash		Mitchell 1905		Rowland Lines in Sun		Substance
Intensity	Wave-Length	Intensity	Wave-Length	Intensity	Wave-Length	Intensity	Wave-Length	
		1*t*	4710.24	2	4709.89	∫2	4709.896	Mn
				3	4710.41	\3	4710.471	Fe
		0	4710.78					
		0	4712.46	0	4712.27	0	4712.260	Ni
6	4713.47	*c* 3	4713.35	4	4713.32	(...	4713.25)	He
		* 3	4714.58	3	4714.58	6	4714.599	Ni
		1	4715.97	2	4715.98	4	4715.946	Ni
		1	4717.19	0	4717.00			
		∫0	4718.18	0	4717.94			
		\1	4718.80	2	4718.61	3	4718.601	Cr
		0	4719.76	1	4719.70	0	4719.690	
		0	4720.39					
		2	4722.31	3	4722.34	3	4722.342	Zn
		1*d*?	4727.58	2*d*	4727.62	∫3	4727.582	Fe
						\2	.676	Mn
		0	4728.80	2	4728.75	4	4728.732	Fe
		1	4729.93	0	4729.64	1	4729.864	Fe?Cr
1	4731.51	3	4731.65	3	4731.64	4	4731.651	Fe?
		1	4733.74	2	4733.79	4	4733.779	Fe
		1	4734.67	1	4734.26	1	4734.283	Fe?
		∫1	4735.91	1	4736.04	3	4736.031	Fe
		\3	4736.77	3	4736.97	6	4736.963	Fe
		\1	4737.69	2*N*	4737.51	∫2	4737.540	Cr
						\1	.817	Fe?
		∫1	4739.38	2	4739.30	3	4739.291	Mn
		\1	4740.33	2*d*	4740.46	00	4740.349	Ni
		∫				1	.530	Fe?
		\0	4741.09			1	4741.131	Crooked
		∫		0*N*	4741.48	1	.260	Fe?
		† \1	4741.78	1	.74	3	.718	Fe
		1	4748.57	1	4748.36	4	4748.325	Fe?
		1	4749.89	2*d*	4749.95	∫0*Nd*?	4749.849	Co
						\1	4750.139	Fe?
		0	4751.11	1	4751.29	0	4751.279	
		0	4752.35	1	4752.20	∫2	4752.289	Ni
				2	.60	\3	.613	Ni
		2	4754.26	3	4754.17	7	4754.225	Mn
		0	4755.40	0	4755.82			
						∫2	4756.300	Cr
		1	4756.63	2	4756.67	\3	.705	Ni
		∫1	4761.89	2	4761.74	3	4761.718	Mn
		\2	4762.74	3*d*	4762.67	5	4762.567	Mn
						1	.820	Ni
		1	4763.59	0	4763.02			
		1	4764.05	4	4764.17	4*d*	4764.108	Ti,Ni
		1	4764.70	1	4764.72	0	4764.720	

* Not chromospheric.

† Many confused lines.

TABLE I—Continued.

Exposure I Chromosphere		Exposure II Flash		Mitchell 1905		Rowland Lines in Sun		Substance	
Intensity	Wave-Length	Intensity	Wave-Length	Intensity	Wave-Length	Intensity	Wave-Length		
		1	4765.86	1*N*	4765.64	2	4765.652		
				1	4766.05	3	4766.050	Mn	
		1	4766.69	1	4766.55	4	4766.621	Mn	
		1	4767.52						
						3	4768.519		
		1*d*?	4768.74	2	4768.45	2	.595	Fe	
						0	.892		
1	4769.92	0	4769.80	0	4769.97	00*N*	4769.991	Ti	
						00	4771.279	Ti-Co	
		* 1*d*?	4771.46	0	4771.32	3	.664		
				1*d*	.79	2	.903	Fe	
		1	4772.18			2	4771.903	Fe	
		1	4773.40	1	4772.97	4	4773.007	Fe	
				0	4773.55	00	.605		
		3	4780.08	4	4780.15	2	4780.169	Co	
		1	4781.68	0	4781.66	000*N*d?	4781.639		
0	4783.10	1	4782.84						
1	4783.71	2	4783.82	4	4783.65	6	4783.613	Mn	
		2	4786.70	3*N*	4786.78	3	4786.727	Ni	
		0	4787.66	0*N*	4787.84				
		1	4788.99	0	4788.92	3	4788.952	Fe	
				3*d*	4789.65	2	4789.525	Cr	
		2	4789.82			3	.849	Fe	
		1	4790.30						
				1*d*	4791.33	0	4791.329		
		1	4791.89						
		1	4792.62	2	4792.57	2	4792.702	Ti-Cr	
		1	4793.46	2	4793.10	1	4793.045	Co	
				0	4798.47	1	4798.453	Fe	
		3*t*	4798.64	2*d*	.79	1	.724		Hazy
						0	.921		
		1	4799.18						
2	4805.29	4	4805.31	5	4805.31	3	4805.285		
						2	4807.179	Ni	
		0	4807.76	0	4807.40	1	.900	Fe	
		0	4809.01	1	4808.68	0	4808.868	Fe	
0	4809.82			0	4809.24				
		† 2*w*	4810.97	2*d*?	4810.62	3	4810.724	Zn	
		1	4811.95	1*d*	4812.25	00	4812.179		
		0	4813.82	2	4813.66	1	4813.661	Co	
		1	4816.39	0	4816.60				
3	4824.04	5	4823.86	5	4823.63	5	4823.697	Mn	
				5	4824.27	3	4824.325	Fe	
		‡ 2	4829.15	2*d*	4829.29	3	4829.214	Ni	
		1	4836.11	2	4836.13	2	4836.059	Fe	
		0*r*	4838.11						

* Hazy and wide.

† Wide and hazy.

‡ In wide band.

TABLE I—Continued.

Exposure I Chromosphere		Exposure II Flash		Mitchell 1905		Rowland Lines in Sun		Substance	
Intensity	Wave-Length	Intensity	Wave-Length	Intensity	Wave-Length	Intensity	Wave-Length		
				1	4839.73	3	4839.734	Fe	
		3	4840.16	2	4840.42	2	4840.449	Co	
						3	.501	Fe	
		1	4841.11	1	4841.00	3	4841.074	Ti	Hazy
		1	4842.99	0	4843.01	1	4842.980	Fe	
				1*d*	.46	3	4843.336	Fe	
		1	4844.14	0	4844.28	1	4844.210	Fe	
		2	4848.05						
0	4848.46	*		2*d*	4848.56	2	4848.438	Ni	
		2	4849.21			1	4849.078	Fe	
0	4855.09	2	4855.09	3?	4855.00	1	4855.059	Fe	
				1	.55	3	.600	Ni	
20	4861.23	*c* 20	4861.49	100	4861.90	30	4861.527	Hβ	
0	4865.03			1	4864.89	0	4864.919	V	
0	4871.33	1	4871.23			3	4870.996	Ni, Cr	
0	4871.76			3	4871.54	5	4871.512	Fe	
0	4872.65	2	4872.26	3	4872.35	4	4872.332	Fe	
		1	4873.90	1	4873.63	2	4873.630	Ni	
						0	4874.196		
0	4876.67			2	4876.59	1	4876.586		
		1	4878.47	3*d*	4878.36	3	4878.313	Ca	
						4	.407	Fe	
				2	4881.75	1	4881.739	V	
						2	.904	Fe	
		2	4882.14	1	4882.36	3	4882.336	Fe	
0	4883.13								
1	4883.94	3	4883.97	6	4883.93	2	4883.867	Yt	
0	4884.48	1	4884.71	1	4884.84	0	4884.779		
				0	4885.61	3	4885.620	Fe	
		0	4886.15	0	4886.18	0	.955	Cr	
				1	.52	3	4886.522	Fe	
		0	4887.22	2*d*	4887.29	2	4887.187	Ni, Cr	
						2	.381	Fe?	
1	4890.96			5	4890.96	6	4890.948	Fe	
1	4891.67	4	4891.67	6	4891.72	8	4891.683	Fe	
		0	4895.09	0	4894.78				
		1	4896.35	0	4896.68	1	4896.625	Fe	
0	4899.44								
		2	4900.14			2	4900.095	Ti La	
1	4900.27	2	4900.41	10	4900.32	2	.301	Y?	
1	4900.77								
		0	4902.00	0	4901.83				
		2*d*	4903.77	2*d*	4903.47	5	4903.502	Fe	
				2	4904.56	3	4904.597		
		2	4905.21	1	4905.33	0	4905.310	Fe?	
						3	4910.198	Fe	
		2*d*	4910.43	1	4910.50	2	.505	Fe	
				1	.79	2	.753	Fe	
		1	4911.38	1	4911.35	1	4911.374		

* In haze around Hβ.

TABLE I—Continued.

Exposure I Chromosphere			Exposure II Flash		Mitchell 1905		Rowland Lines in Sun		Substance
Intensity	Wave-Length		Intensity	Wave-Length	Intensity	Wave-Length	Intensity	Wave-Length	
			0	4913.27	0	4913.38			
1	4914.81		1	4914.39	1	4914.17	2	4914.150	
					1	4917.42	2	4917.410	Fe
			1	4918.07			1	4918.190	Fe
0	4918.73				2	4918.55	2	.543	Ni
		c	2	4919.11	3	4919.20	6	4919.174	Fe
1	4919.55				1	4920.02			
1	4920.49	*c	2	4920.69	4	4920.68	10	4920.685	Fe
1	4921.18	*c	2	4921.25	1	4921.10	0	4921.147	La
							1	.963	La Ti
2	4922.03		1	4922.28	3*d*	4922.19	...	(4922.10)	He
2	4922.49						2	4922.446	Cr
4	4924.18	*c	8	4924.24	20	4924.14	5	4924.107	Fe
					0	4925.01	3	.956	Fe
2	4934.06	*c	8	4934.29	12	4934.26	3	4934.214	Ba
2	4934.61						4	.277	Ba
			1	4937.89	0	4937.59	3	4937.524	Ni?
					0	4938.30	2	4938.350	Fe
			2	4938.97	0	4939.02	4	4938.997	Fe
			2	4940.07	1	4939.83	3	4939.868	Fe
					0	4940.35			
			1	4946.48	2	4946.59	3	4946.568	Fe
1	4957.01						5	4957.480	Fe
2	4957.85		5	4957.82	8*d*	4957.68	8	.785	Fe
		†	0	4966.10	1	4966.33	4	4966.270	Fe
			0	4973.22	4	4973.20	4	4973.281	Ti-Fe
			2	4982.24	2	4981.89	4	4981.912	Ti
					0*d*	4982.69	4	4982.682	Fe
			2	4983.88	1*d*?	4983.56	3	4983.433	Fe
					2*d*	4984.14	3	4984.028	Fe
			1	4984.88			2	.297	Ni
					1	4985.47	3	4985.432	Fe
			1	4985.85	1	.77	3	.730	Fe
			0	4986.90	0	4986.80			
			0	4988.95	2	4989.17	2	4989.130	Fe
			2*d*	4991.38	3	4991.29	3	4991.247	Ti
							2	.452	Fe La
					1*d*?	4993.65	0	4993.531	
			2*d*	4993.97			0	.864	Fe Ragged
					1	4994.25	3	4994.316	Fe
			1	4999.61	2*d*	4999.67	3	4999.689	Ti, La
			1	5001.98	3	5002.02	5	5002.044	Fe
					0*d*	.83	2	.976	Fe
			0	5003.59	1*d*	5003.90	3	5003.924	Ni
			3	5006.04	2	5005.86	4	5005.896	Fe
					2	5006.31	5	5006.306	Fe
			2	5007.55	2*d*	5007.41	3	5007.398	Ti
							2	.461	Fe

* Maxima in broad patchy chromospheric line.

† Faint band between.

TABLE I—Continued.

Exposure I Chromosphere		Exposure II Flash		Mitchell 1905		Rowland Lines in Sun		Substance	
Intensity	Wave-Length	Intensity	Wave-Length	Intensity	Wave-Length	Intensity	Wave-Length		
		1*d*?	5012.53	2	5012.25	4	5012.252	Fe	
				0	.67	1	.625	Ni	
				1	5013.32	2	5013.479	Cr, Ti	
		1	5014.41	1	5014.43	2	5014.369	Ti	
						3	.457	Fe	
		1	5015.04	0	5015.16	3	5015.123	Fe	
		1	5015.81	2	5015.86	...	(5015.73)	He	
4	5016.12			0	5016.32	2	5016.340	Ti	
		1	5016.70	0	5017.20				
				0	5017.70	3	5017.762	Ni	
6	5018.79	*c* 6	5018.70	15	5018.61	4	5018.629	Fe	
		* 1	5019.81	0	5019.94				
		1	5020.22	1	5020.20	2	5020.208	Ti	
		0*d*	5023.35	2	5023.05	2	5023.052	Ti	
				0	.37				
		1	5025.24	1	5025.00	3	5025.027	Ti	
		1	5026.14	1	.70	1	.749	Ti	
		1	5027.69	2	5027.36	3	5027.305	Fe	
				0*d*	5028.13	2	5028.308	Fe	
		1	5029.88	1	5029.79	1	5029.805	Fe	
		4	5031.27	5	5031.18	3	5031.199		Hazy
		0	5034.59						
		1	5035.64	1	5035.58	5	5035.542	Ni	
				1	5036.09	3	5036.089	Ti	
		2	5036.22	0	.43	2	.155	Ni	
				0	.67	2	.645	Ti	
		0	5038.33	2	5038.59				
		1	5039.47	0	5039.40	3	5039.428	Fe	
		1	5040.39	1	5040.16	3	5040.138	Ti	
						3*d*?	5041.069	Fe	
		2	5041.31	2	5041.15	4	.255	Fe	
				3*d*	.89	2	.795	Ca	
		3	5042.18	1	5042.36	4	.936	Fe	
						1	5042.367	Ni	
		1	5045.81	0	5045.56				
†		1	5048.36	0	5048.21	0	5048.242	Ni	
				1	.64	2	.612	Fe	
		1	5049.53	1	5049.06	2	5049.035	Ni	
				2	5050.03	6	5050.008	Fe	
		1	5050.77	0	5050.88				
		2	5051.37						
						1	5051.683	Ni	
		1	5052.22	2*d*	5051.84	4	.825	Fe	
						0	5052.084	Cr	
‡		1	5053.27	1*d*	5053.09	0	5053.056	Ti	
		1	5064.16			00	5064.244	Ti	
				1	5064.74	3	.836	Ti	
		1	5065.40	2	5065.26	3	5065.207	Fe	
						2	.380	Fe	

* At edge of preceding.

† Beginning of band.

‡ End of band.

TABLE I—Continued.

Exposure I Chromosphere		Exposure II Flash		Mitchell 1905		Rowland Lines in Sun		Substance
Intensity	Wave-Length	Intensity	Wave-Length	Intensity	Wave-Length	Intensity	Wave-Length	
		2	5079.19	3*d*	5079.27	3	5079.158	Fe
						4	.409	Fe
		•3*d*	5080.37	2*d*	5080.02	4	.921	Fe
				1	.76	4	5080.714	Ni
		1	5081.31	1	5081.31	3	5081.286	Ni
		2	5083.03	1*d*?	5082.74	2	5082.526	Ni
				2	5083.54	4	5083.518	Fe
		2	5084.35	2	5084.30	3	5084.279	Ni
		1	5087.09	0	5087.21	0	5087.239	Ti
				3	.62	1	.601	Y?
		1	5088.14	0*d*	5088.45	0	5088.331	
		1	5097.14	1	5097.18	0	5097.038	Ni
		†				3	.175	Fe
		2	5098.71	0	5098.29	1	5098.752	Fe
				1	.89	3	.885	Fe
		2	5099.86	0	5099.39	1	5099.497	Ni
				1	5100.03	2	5100.108	Ni
		1	5101.16	0*N*	5100.99			
						4	5107.619	Fe
		2	5107.95	3*d*	5107.75	4	.823	Fe
		3	5110.46	2	5110.63	5	5110.574	Fe
		1	5111.90	1	5111.83			
		1	5115.52	2	5115.58	2	5115.566	Ni
		‡1	5122.87	0	5122.50			
				2	5123.14			
		2	5124.05	2	.90	3	5123.899	Fe
		1	5125.09	2	5125.30	3	5125.300	Fe
				1	5126.40	2	5126.371	Fe-Co
		0	5127.56	0	5127.52	3	5127.533	Fe, Ti
		2	5129.28	3*d*	5129.41	3	5129.336	Ti?
						2	.546	Ni
		1	5131.74	2	5131.66	2	5131.642	Fe
				2	.92	1	.942	Ni
		¶1	5134.20	3	5133.82	4	5133.870	Fe
				0*d*	5134.64			
		1	5137.63	2	5137.59	3	5137.558	Fe
		1	5139.23	0	5139.42	4	5139.427	Fe
		2	5139.84	2	.60	4	.644	Fe
		1	5142.65	3	5142.67	4*d*?	5142.693	Fe
				2	5143.05	3	5143.111	Fe
		1	5143.66					
		1	5151.19	2*d*	5150.89	4	5151.020	Fe
		1	5152.25	1	5152.05	3	5152.087	Fe
		1	5154.02					
				3	5154.27	2	5154.244	Ti-Co
		1	5154.65					

• Bright band.

† Band with ragged, ill-defined lines.

‡ Edge of band of confused lines.

¶ At edge of band.

TABLE I—Continued.

Exposure I Chromosphere		Exposure II Flash		Mitchell 1905		Rowland Lines in Sun		Substance	
Intensity	Wave-Length	Intensity	Wave-Length	Intensity	Wave-Length	Intensity	Wave-Length		
						{1	5155.303	Ni	
		1	5155.98	2*d*	5155.68	{2	.935	Ni	
		1*r*	5159.14			2	5159.231	Fe	
		{0	5161.74	1	5161.86				
		c {		2	5162.50	5	5162.449	Fe,C	
		{1	5163.06	0	5163.07				
				0	5163.60				
		0	5164.05	0	5164.43				
				0	.88				
		1	5165.11	2	5165.35				
		1	5166.48	1	5166.43	3	5166.544	Cr-Fe	
{1	5167.16					{15	5167.497	Mg	b_4
{2	5167.72	*c* 5	5167.54	12	5167.54	{ 5	.678	Fe	
4	5169.25	*c* 6	5169.29	15	5169.18	{3	5169.069	Fe	b_3
						{4	.220	Fe	
				2	5171.75	{ 6	5171.778	Fe	
5	5172.97	*c* 6	5173.03	20	5172.82	{20	5172.856	Mg	b_2
				2	5173.92	{ 2	5173.917	Ti	
		1*d*?	5177.33	0	5177.62	0	5177.410	Fe	
		0	5179.84	0	5180.28	1	5180.23	Fe	
4	5183.89	*c* 8	5183.95	25	5183.74	30	5183.791	Mg	b_1
		2*d*	5188.93	4	5188.85	{2	5188.863	Ti	
						{3	5189.018	Ca	
		1	5191.56	3	5191.66	4	5191.629	Fe	
		2*t*	5192.96	{3	5192.60	{5	5192.523	Fe	
				{0	5193.14	{2	5193.139	Ti	
		1	5195.08	3	5795.15	4	5195.113	Fe	
				1	.65	2	.647	Fe	
		1	5196.21	0	5196.26	1	5196.227	Fe	
		2*d*	5197.85	4	5197.73	{2	5197.743		
				0	5198.11	{0	5198.108		
		0	5199.09			3	5198.888	Fe	
						{00	5209.355	Cr	
		1	5200.54	2*d*	5200.45	{ 0	.590	V	
		0	5201.82	1	5201.31				
		1	5202.40	2*d*	5202.43	{2	5202.439	Fe?	
						{4	.516	Fe	
		{1	5204.59	3*d*	5204.70	{5	5204.680	Fe	
						{3	.768	Fe	
		c 3*w*	5206.19	6*d*	5206.06	5	5206.215	Cr-Ti	
		c 3*w*	5208.77	5	5208.54	{5	5208.596	Cr	
						{2	.776	Fe	
		2	5210.70	1*d*	5210.98	{3	5210.555	Ti	
		1	5212.64	0	5212.34				Narrow
				0	.90				
		1	5213.75						
		{1	5215.72	1	5215.35	{3	5215.353	Fe	"
		{1	5216.27	2	5216.47	{3	5216.437	Fe	"
		{1	5217.18	1	5217.56	{3	5217.552	Fe	
		{0	5218.42	1*d*	5218.31	{1	5218.369	Fe	

TABLE I—Continued

Exposure I Chromosphere		Exposure II Flash		Mitchell 1905		Rowland Lines in Sun		Substance	
Intensity	Wave-Length	Intensity	Wave-Length	Intensity	Wave-Length	Intensity	Wave-Length		
				0	5225.63	2	5225.695	Fe	
				4	5226.69	2	5226.707	Ti	
		* 5*w*	5227.05	3	5227.20	3	5227.043	Fe-Cr	
						5*d*?	.362	Fe	
		1	5232.73						
				2	5233.15	7	5233.122	Fe	
		1	5233.59						
		2	5234.70	5	5234.80	2	5234.791		
		0	5235.79	1	5235.59	1	5235.557	Fe	
		1*d*	5250.37	1	5250.33	2	5250.385	Fe	
				2	.82	3	.817	Fe	
		1*d*	5252.69	0	5252.61				
		1*d*	5254.27	0	5253.70	2	5253.633	Fe	
			5255.18	1	5254.93	3	5255.121	Fe	
		1*d*	5256.30	1*N*	5255.32				
				0	5257.10				
		0	5259.53	1	5259.48				Narrow
		0*d*?	5261.93	2	5261.86	3	5261.876	Ca-Cr	
				2	5262.37	3	5262.419	Ca	
				0	5263.08				
		0	5263.21	1	.56	4	5263.486	Fe	
				0	5264.04	4	5264.329	Cr	
		1	5264.38	1	.37	3	.415	Ca	
				1	.93	0	.976	Fe	
		1	5265.49			3	5265.729	Ca	
				1*d*	5265.87	2	.893	Ni-Cr	
		2	5266.46	2	5266.77	6	5266.738	Fe	
						8	5269.723	Fe	
		c 4*w*	5270.18	8	5269.72	3	5270.438	Ca	
				6	5270.49	4	.558	Fe	
		0	5273.20			3	5273.339	Fe	
				3*d*	5273.61	2	.558	Fe-Cr	
						1	5275.926	Cr	
		3*t*	5276.26	10	5276.16	3	5276.169	Fe?	
						2	.237	-Cr?	
		1	5281.39	1	5280.62	1	5280.540	Fe	Narrow
				2	5281.97	5	5281.971	Fe	
		1	5282.68	0*N*	5282.45				"
		2	5283.76	2	5283.81	6	5283.802	Fe	"
				3	5284.29	1	5284.281	Ti	
		1	5284.74	0	5285.27	0	5285.300	Ni	"
				1	5292.65				
		0	5293.07	2	5293.32				
				1	5296.86	3	5296.872	Cr	
		† 0*w*	5298.17	1	5297.57	2	5297.555	Cr	
				2	5298.46	1	5298.194	Cr	
				0	.99	4	.455	Cr	
						0	.957	Fe	

* Middle of wide line.

† Wide and hazy.

TABLE I—Continued.

Exposure I Chromosphere		Exposure II Flash		Mitchell 1905		Rowland Lines in Sun		Substance
Intensity	Wave-Length	Intensity	Wave-Length	Intensity	Wave-Length	Intensity	Wave-Length	
		0	5301.73					Narrow
		* 1	5303.10	2*d*	5302.44	5	5302.480	Fe
						...	(5302.98)	Coronium ?
		c 4	5316.83	12	5316.83	4	5316.790	Fe
		1	5318.51	0*N*	5318.48	00*N*	5318.534	
		2	5324.88	4	5324.40	7	5324.373	Fe
				3	5325.76	2	5325.738	
		1	5327.53					
				8	5328.20	8*d*?	5328.236	Fe
		2	5328.40	6	.65	2	.515	Cr
						2	.696	Fe
						2	.747	Fe
		1	5329.34	0	5329.36	3	5329.329	Cr
				1	5330.14	1	5330.179	Fe
		1	5330.63	0	5330.78			
						1	5332.849	Co,Fe
		1	5332.60	2*d*	5333.02	4	5333.089	Fe
		1*w*	5337.00	5	5336.94	4	5336.974	Ti,-
				2	5340.16	6	5340.121	Fe
		1	5340.79			0	.639	Cr
				3*d*	5341.28	7	5341.213	Fe
		1	5341.87	0	5341.68	1	.337	Mn
				2	5342.87	1	5342.890	Co
		1	5345.63	2	5345.99	5	5345.991	Cr
		0	5346.92	1	5346.77	0	5346.731	Fe
		0	5349.70	2	5349.64	4	5349.653	Ca
				1	.88	1	.928	Fe
		0	5352.53	2*N*	5352.18	1	5352.234	Co
		0	5353.52	5*d*	5353.60	3	5353.571	Fe,Cr
		0	5354.07			0	5353.702	Co
		1	5361.87	1	5361.76	1	5361.813	
		2	5362.72			1	5362.944	Fe,Co
		1	5363.37	8	5363.05	3	5363.058	Ni
		1*d*?	5364.70	0	5364.66			
				3	5365.04	5	5365.069	Fe
				3	.53	3	.596	Fe
		1	5366.38	0*d*?	5366.79			
		1	5367.82	3	5367.64	6	5367.669	Fe
		1	5369.55	1	5369.81	1	5369.782	Co-Ti
				3	5370.16	6	5370.166	Fe
		1	5370.97			1	5371.528	Ni
				8	5371.69	4	.656	Cr
		2	5372.05			3	.743	Fe
		1	5373.27	0	5372.73			
				1*d*?	5373.82	2	5373.905	Fe,Cr
		0	5374.56					
				2	5377.80			
		0	5378.75					
				2	5379.70			

* Close to edge of coronium band.

TABLE I—Continued.

Exposure I Chromosphere		Exposure II Flash		Mitchell 1905		Rowland Lines in Sun		Substance
Intensity	Wave-Length	Intensity	Wave-Length	Intensity	Wave-Length	Intensity	Wave-Length	
		*c 1	5381.03	4	5381.23	2	5381.221	Fe
		1	5382.26	0N	5382.26	0	5382.469	
		1	5383.64	3	5383.50	6	5383.578	Fe
		0	5384.72					
				0	5385.75			
		0	5386.47			1	5386.534	Fe
		0	5389.33	2	5389.67	3	5389.683	Fe
		0	5390.85	1d	5390.50	0	5390.725	
		0	5391.83	2	5391.61	2	5391.660	Fe
				1	.84	1	.820	Fe
		1	5393.17	3	5393.39	5	5393.375	Fe
		1	5394.58	2d	5394.86	1	5394.839	Mn
						1	.913	Mn
		1	5396.84					
				6	5397.34	7	5397.344	Fe
		2	5397.86	0	.85	1	.822	Fe
				2	5398.46	3	5398.486	Fe
		0	5400.65	3	5400.65	3	5400.711	Fe
		1	5403.78	2	5403.97	2	5404.028	Fe
				6	5404.31	5	.357	Fe
		1	5404.94					
		1	5405.55	1	5405.58	1	5405.554	
				8	5406.04	6	.989	Fe
		1	5406.57	1	5407.00	1	5406.980	
		0	5407.67	2d	5407.70	0	5407.587	Mn
						0	.688	Mn
		1	5409.20	1	5409.36	2	5409.339	Fe
				2	5410.01	4	5410.000	Cr
		1	5410.80					
				4	5411.09	4	5411.124	Fe
		0	5411.87	1	5411.43	1	.428	Ni
		1	5415.17	3	5415.43	5	5415.416	Fe-V
		0	5416.56	0	5417.25	0	5417.247	Fe
		1	5418.54	0	5418.35	000N	5418.357	
				4d	5419.00	1	5418.979	Ti?
		1	5420.73	2	5420.49	0N	5420.510	Mn
						0N	.613	Mn
		0	5421.55	1	5421.14	0N	5421.381	
				5	5424.27	6	5424.290	Fe
		† 3w	5425.23	2	5424.85	1	.860	Ni
				4	5425.50	1	5425.464	
		1	5428.41					
						1	5429.717	
		4w	5430.05	10	5429.93	6d?	.911	Fe
						0	5430.062	
		1	5431.51	1	5431.80			Narrow

[*To be Continued.*]

* Sharp in sun; hazy and wide in chromosphere.

† Probably three or more lines.

PLATE XXVIII

(Figure 1.)

Great Comet of 1901, May 11th,

photographed by Mr. E. E. Barnard in Sumatra. Invisible to residents of the United States, it was a glorious apparition from southern countries favored by good weather at the time of its unheralded appearance.

A YEAR OF COMETS.

DI VICO'S 1846 COMET POSSIBLY DUE AGAIN IN 1919. OTHER COMETS DUE THIS YEAR.

MAYNARD SHIPLEY.

Perhaps no one living today remembers Di Vico's long-period comet of 1846 (iv). With a period of approximately 75.71 years, with an uncertainty of three years, according to von Hepperger (1887), who has given us the most reliable elements of its orbit, this comet may appear at any time from 1919 to 1925.

Four or five comets have been observed by astronomers during the past winter and spring, and several more periodic visitants should be 'picked up" by the larger telescopes before Christmas shall again have been celebrated. Long regarded as harbingers of "war and pestilence," these "hairy stars" may now be thought of in terms of peace and the new League of Nations!

Or will their reappearance coincide with the spread of Bolshevism, and the prolongation of war?

Di Vico's comet (1846 iv) was first discovered by Professor W. C. Bond, of the Harvard University Observatory, Cambridge, Massachusetts, on February 26, just before the outbreak of the Mexican War. It was not until two days later that the comet was discovered by Professor F. Di Vico, of Rome, Italy, whose name the celestial visitor now bears. The "Mexican War comet" was under observation for two months, and its orbit was then computed, giving this interesting object a period of about 75 years. This means that Di Vico's comet has made a very long journey since its last visit to the all-controlling sun, namely, about 34 times the distance between earth and sun.

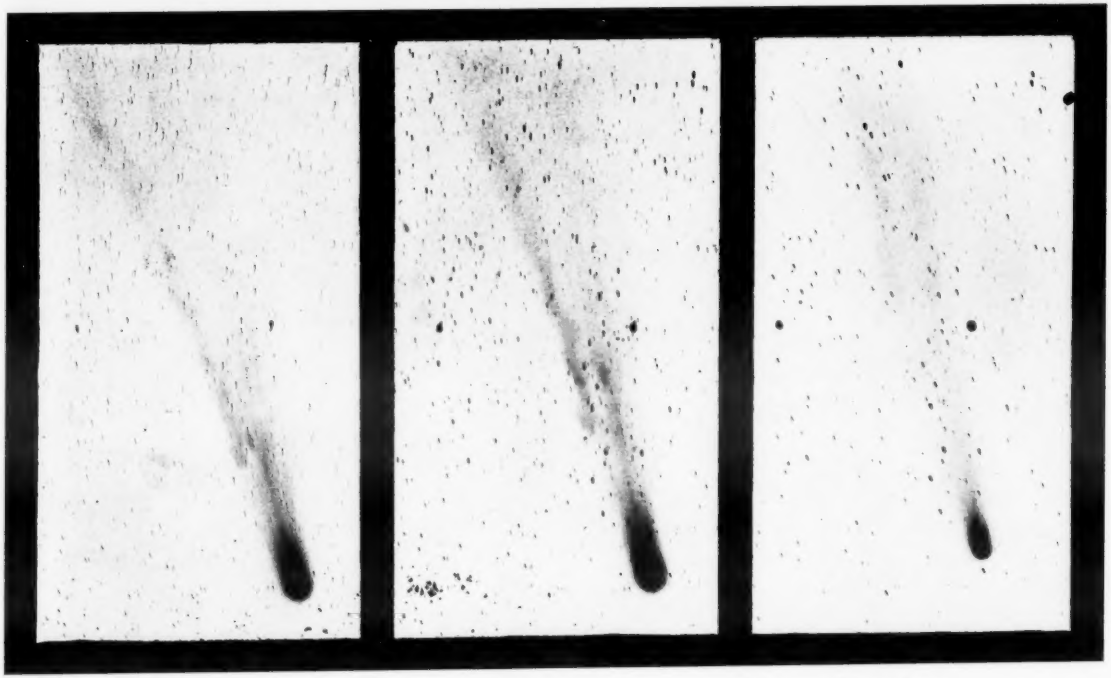
Anyone who has ridden in an automobile at a speed of a mile a minute knows that the "going" is quite fast enough. However, compared with the speed of a comet in its elliptical orbit around the sun, a mile a minute would be considered a snail's pace. At this average speed it would require more than ten thousand years for Di Vico's comet to traverse the pathway it has covered since its departure in 1846—i.e., about seven billion miles! The velocity of comets increases greatly as they near our Lord of Day, and diminishes as they recede from perihelion. Di Vico's comet should now be well within 300,000,000 miles of the earth, somewhere between the orbits of Mars and Jupiter.

Will Di Vico's comet return refulgent in glory of long, diaphanous tail and glowing nucleus? No one can answer "yes" or "no" with any degree of certainty; for Di Vico's comet has been observed and identified on but one visit, and the splendor of comets depends not only upon their intrinsic brightness, which is variable,—but also largely upon what chemical elements compose head, nucleus, and tail. It has also been noted that solar storms, indicated by violent sun-spot activity, result in what appears to be bombardment of the cometary matter by the sun's cathode rays, or negatively charged ions, with accompanying increase in the comet's luminescence. Again, the splendor of cometary apparitions varies with the relative positions in space of comet and observer.

In 1901, observers south of the equator were delighted by the apparition of a brilliant comet not seen by residents of the Northern Hemisphere at all. This remarkable comet (1901 i) was discovered at Paysander, in South America, on April 2. At one time its main tail, which did not exceed 10° in length, was preceded by a faint tail fully 30° long, which branched out from the main tail, making with it an angle of about 40° or nearly half a right angle. Like the great comet of 1882, its main tail seemed to be sheathed in a gauzy secondary envelope. The spectrum appeared to be continuous, as if most of its light were but reflected sunshine. The comet was visible for more than six weeks, but bad weather both at the Cape of Good Hope and in Australia, and also the comet's inconvenient position with respect to the sun, interfered very much with satisfactory observations. On May 2 the nucleus is said to have rivalled Sirius in brilliancy. The accompanying photograph (Figure 1) of the comet, taken in Sumatra by the eminent astronomer E. E. Barnard, of the Yerkes Observatory, with an exposure of 27 minutes, gives a good idea of the peculiar double-tailed aspect of the great southern comet, as it appeared on May 11.

Halley's comet, in 1910, though fairly well observed by the people of the United States, was a far more brilliant spectacle as viewed by the residents of South America, New Guinea, Australia and New Zealand, who saw it as "a magnificent object with a tail extending half over the celestial vault."

When Di Vico's comet reappears, it will first be seen, telescopically, as a faintly glowing spherical object of hazy or nebulous aspect, later developing a nucleus of star-like luster. Approaching our region of space, with ever accelerating speed, its enveloping gases, frozen solid by the inconceivably low temperature of far-distant space, will begin to glow and expand in the warm rays of the energizing sun. The hydrocarbon substances in which the more or less solid nucleus is enveloped will first be vaporized by the solar heat, then minute parti-



YERKES HONOLULU BEIRUT-SYRIA

(FIGURE 2.)

Halley's Comet was a brilliant spectacle in 1910, as viewed by persons south of the equator, with a glowing tail "extending half over the celestial vault." The photographs show the comet as it appeared on June 6, 1910, as photographed at Yerkes Observatory, Honolulu, and Beirut, Syria. Less than 14,000,000 miles distant on May 18th, the comet of June 6th was about 80,000,000 miles from the earth.

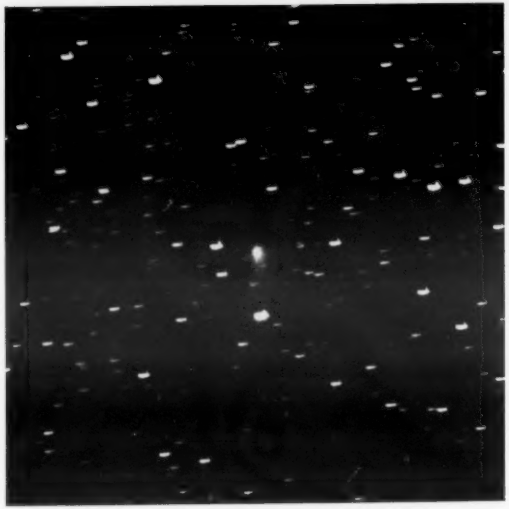
(FIGURE 3.) September 30.

(FIGURE 4.) October 3.

(FIGURE 5.) December 9.

THREE VIEWS OF MOREHOUSE'S COMET OF 1908,

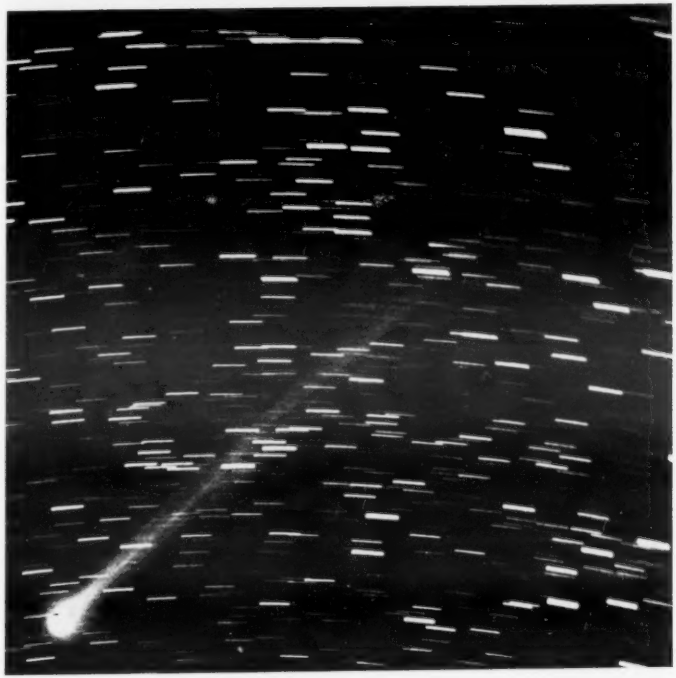
showing remarkable changes in aspect of both head and tail during four months. This now famous comet, discovered September 1, 1908, by photography, was visible (telescopically) for ten months, traversing the celestial vault from the North to the South Pole. The photographs disclose much more detail in the comet's appearance than was seen by direct observation with the world's greatest telescopes, owing to the sensitiveness of the photographic plates to the ultra-violet rays, not visible to human eyes.



(Figure 6.)

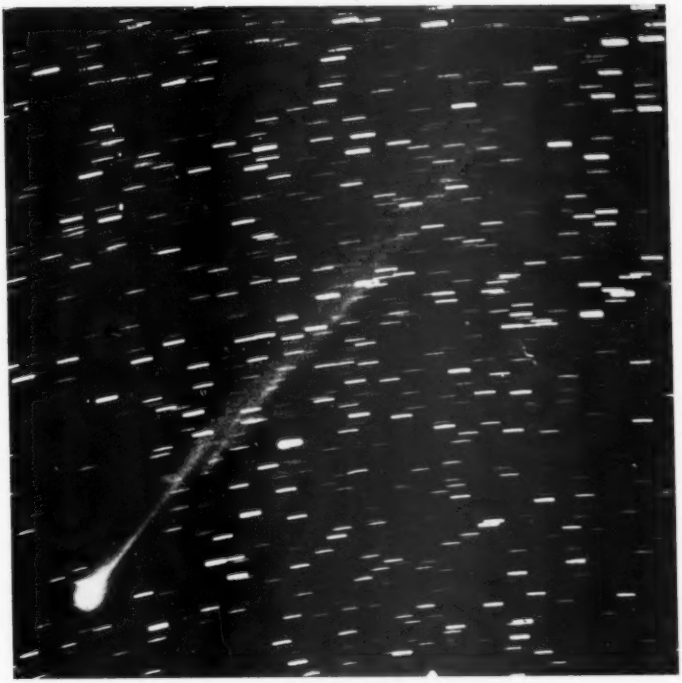
Faye's Telescopic Comet,

discovered August 19, 1888; after Encke's, the best known and most regular of celestial visitants, with a period of 7.44 years. The accompanying photograph, taken on November 10, 1910, at the Yerkes Observatory, is a typical example of the short-period comets when nearest the earth.



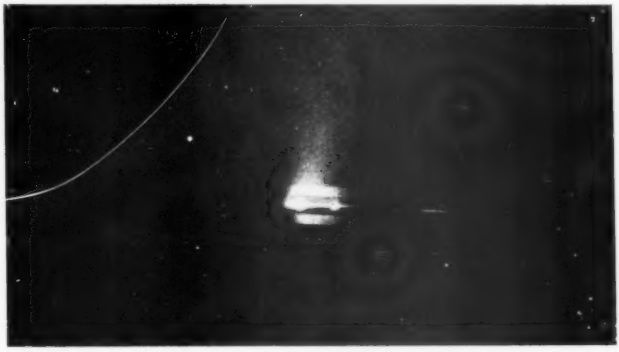
(Figure 7.)

Borrelly's Short-Period (Seven Years) Comet of 1903 (iv), discovered June 11th, and photographed July 22nd, at the Yerkes Observatory, by Mr. R. J. Wallace. It remained visible for nineteen weeks.



(FIGURE 8.)

Borrelly's Comet on July 24th, showing transverse division of the tail. Exposure two hours and 37 minutes. The white streaks are star trails, the camera being focussed on the rapidly-moving comet, and the star images thus being drawn out into parallel streaks.



(FIGURE 10.)

Spectrum of the head of Halley's Comet, May 5, 1910, showing the presence of the deadly cyanogen gas; but this band does not extend to the tail of the comet, hence we experienced no discomfort by our plunge into millions of miles of the comet's tail on May 18, 1910.

cles of cometary dust will be first drawn sunward by gravity and then violently repelled by the pressure of the solar light waves, the latter being more potent than gravitation where particles from $\frac{1}{10,000}$ to $\frac{1}{45,000}$ of a millimetre are concerned. Lightwaves vary in force according to the square of a particle's diameter, whereas the attraction of gravitation varies as the cube of its diameter. It is this finely divided matter, at once illumined and repelled by the sun's rays,—though often shining by its own intrinsic luminescense,—that forms the beautiful and impressive cometary tails, with their evanescent forms (Figures 3, 4 and 5). Spectroscopic investigation of Morehouse's comet (1908) revealed the fact that this remarkable body owed its effulgence mostly to its own molecular activity or chemical composition.

Sometimes entirely wanting or scarcely detectable, the tail is often an appendage tens of millions of miles in length, the actual length of the tail of the comet of 1882 (iii) being 100,000,000 miles; while that of the comet of 1843 (i) streamed across the heavens for a distance of 200,000,000 miles, thus extending for a distance greater than that which separates the sun from the planet Mars! The diameter of the tails of comets at the end remote from the head varies from 1,000,000 to 15,000,000 miles. The heads of comets vary greatly in size, but the coma of an average bright comet is about 50,000 miles in diameter. If the diameter were as small as 10,000 miles, we should scarcely be able to discover it. The head of the marvellous comet of 1811 was 1,200,000 miles in diameter. Most exceptional was Holmes' comet of 1892-3, which, with a head of the enormous diameter of 800,000 miles, yet displayed neither nucleus nor tail, and gave a "continuous spectrum," its glow being due merely to reflected sunlight. For a time during its visit in 1835, Halley's comet, also, was tail-less, as has been noted also in a few other cases, even of large comets. In the case of the smaller telescopic comets, the tail is often either absent or hardly discernible, as in Faye's short-period comet (Figure 6), a good example of the telescopic appearance of short-period comets,—i.e., those with periods of less than ten years.

Some of the short-period comets, on the other hand, display a tail of considerable proportions, after long exposure and the employment of specially prepared plates. The beautiful photographs of Borrelly's comet of 1903 (iv), made by Mr. Wallace with the great Bruce photographic telescope, are interesting examples in point (Figures 7 and 8).

To the question, "What are comets?" perhaps the best answer so far given is that they are composed of star-dust, gases, and meteoric matter, gathered from the far outskirts of the parent nebula from which

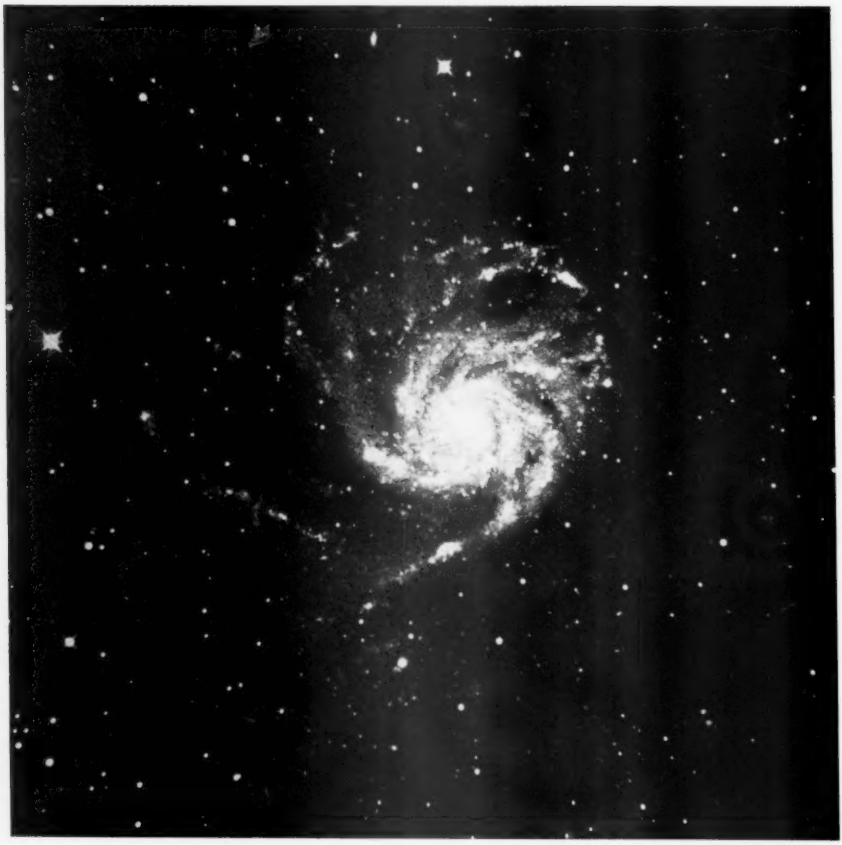
our planets were derived (Figure 9). Had the cosmic material been more abundant within the sphere of attraction of the comets' developing nuclei, they would in time have become small planets, perhaps only to be captured later by the giant Jupiter as satellites, or by Saturn, Uranus or Neptune, with orbits becoming ever more nearly circular as a result of collision with the still richly diffused nebular material, acting as an effective "resisting medium." (The planetary orbits themselves were originally elliptical, not comparatively circular, as now, according to Dr. T. J. J. See.)

When Di Vico's comet visited the region of the earth's orbit in 1846, the spectroscope had not yet been brought into use as an instrument of astronomical research, Donati's comet of 1864 (i) being the first comet whose composition was subjected to spectroscopic analysis. The employment of short-focus prismatic cameras, first used by Count de la Baume-Pluvinel, in 1902, along with specially designed spectroscopes, has added greatly to our knowledge of the composition of comets. While many comets reveal to us only reflected sunlight, the bright bands of gaseous hydrocarbons are usually conspicuous, and on near approach to the sun the vapors of iron, calcium, sodium, and magnesium are often prominently revealed. Nitrogen and oxygen, also, have been noted, and in the head (but not in the tail) of Halley's comet and several others the deadly gas cyanogen has been shown by the spectroscope (Figure 10).

Comets visible at the beginning of 1919 included Wolf's (1918 iv) and Borrelly's (1905 ii) periodic comets, and Shorr's new comet (1918 d). Kopff's (1906 e) should have appeared in July; Encke's comet, famous because of having the shortest period of any known comet, 3⅓ years, will be at perihelion again about November 17. The aphelion distance of Encke's comet is but 388,550,000 miles. The greatest known, that of the comet of 1844 (ii) is 406,130,000,000 miles.

The Temple-Swift comet was due in February, but was not observed, being unfavorably situated. Finlay's short-period comet (6.54 years) is due and will be found without great difficulty during this year's apparition. The very large but tail-less Holmes' comet, first seen in 1892, is due in December. A short-period comet known as "DiVico's lost comet of 1844" may also appear, if, as contended by Professor Schulhof, this is the same comet which was observed and investigated by E. Swift in California, on November 20, 1894. The elements of the comet of 1894 were found to correspond very closely to those assigned to Di Vico's comet of 1844. Other comets due in 1919 are Barnard's (1892 v), Brooks' (1886 iv), and Giacobini's (1900 iii). The last three were not seen at intervening returns, and are not likely to be visible during the present visit to perihelion.

PLATE XXXIII



(Figure 9.)

The Great Spiral Nebula, Messier 101, in Ursa Major,

taken with the two-foot reflector at the Yerkes Observatory. The spiral nebulæ known to us are probably all too vast in their dimensions to be solar systems like ours in the making, but they give a good idea of what our parent nebula was like, and there are sound reasons for assuming that our comets were mostly derived from the residual material left on the far outskirts of the parent nebula.

(FIGURE 11.)

Comet 1910 (i), which appeared unexpectedly in January of that year, many persons mistaking it for the famous comet of Halley. Taken at the Yerkes Observatory, on January 24th.

(FIGURE 12.)

The same, taken on February 3rd, showing tail much curved, and broad for about 4°. The exposure was 38 minutes, taken with the six-inch Bruce lens.

With the exception of De Vico's comet of 1846 (iv), no known long-period comet is expected until 1922, when Brorsen's comet of 1847 (v) will be due. Its orbit was investigated by several astronomers, and the period of 74.97 years, assigned to it by D'Arrest, is regarded as authoritative. At its last return to perihelion, it was visible for about two months.

Apart from the expected visit of Di Vico's comet of 1846, we may reasonably look for the appearance of a bright *unexpected* comet in the near future. The greatest recorded comet, that of 1843 (i), suddenly appeared unannounced, just as did the January comet of 1910 (Figures 11 and 12).

During the nineteenth century we were favored with 335 visible cometary wanderers, and on the average of *once in eight years* during the latter half of this long period a very bright comet appeared. During the past quarter of a century we have had no celestial guests comparable in splendor to the comet of 1882, which was clearly visible to the naked eye in broad sunlight; nor even to Coggia's comet of 1874, to say nothing of that wonder of 1843 (i), which passed within 50,000 miles of the sun's surface, and at the unthinkable speed in its orbit of 1,000,000 miles an hour. No marvel that this amazing sky vagrant, with its tail of more than 200,000,000 miles in length, was, like the great comet of 1882, visible in full daylight!

Let us hope for another sublime apparition before the close of 1919, whether it be the return of Di Vico's periodic comet of 1846, or some majestic stranger, such as the eleven-tailed comet of 1744. We cannot patiently await the return of the awe-inspiring comet of 1811, which Napoleon declared presaged success for his invasion of Russia,—since it is not scheduled to return until about the year 2199!

San Francisco, California.

THE PULFRICH SEXTANT.

F. J. B. CORDEIRO.

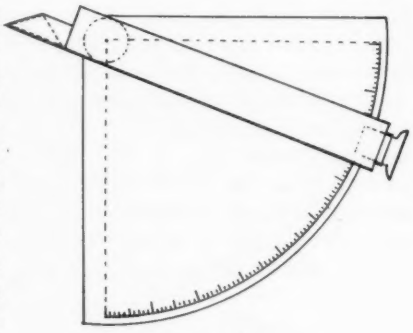
Hitherto observational navigation has been impossible at night. With the coming of darkness, the horizon vanishes and with it all possibility of taking an altitude. On land, artificial horizons consisting of surface of quicksilver, molasses, etc., are substituted, but at sea those are impossible. A horizonless sextant has long been a great desideratum and attempts have been made to obtain the necessary level surface from which to measure an altitude by attaching a spirit level to an ordinary sextant, but the success has been meagre. The reflected image of the

observed object is brought into line with the bubble and the observer tries to estimate when the centre of the moving bubble coincides with the object.

Many years ago, I was shown such a "bubble" sextant by a nautical instrument maker in San Francisco. He told me that he rarely sold one and that they were of use only in certain cases where a result having a wide margin of unknown error was better than having no measurement at all.

Several years ago the first horizonless sextant which could lay any claim to accuracy, was constructed by Dr. Carl Pulfrich, head of the department of instruments of precision, (Mess-Abteilung), of the Carl Zeiss works of Jena, Germany. Dr. Pulfrich represents a type hitherto rare outside of Germany, viz., a man of high scientific attainments engaged in commercialized science. Had it not been for his patient and ingenious experimentation, it is doubtful if we should have had such an instrument for many years. When he has once decided that an idea is feasible and desirable, there are few men abler to put it into practical form, as is evidenced by the many valuable instruments he has produced.

The figure represents the instrument diagrammatically. It is essentially a sector carrying an arm which supports a small telescope. In front of the objective is an isosceles reflecting prism, rigidly attached, its base being parallel to the axis of the telescope. The sector which is graduated, and the arm which moves over it, are pivoted at the center of the arc, and the whole is supported on a handle behind the sector (not shown) as in an ordinary sextant. The pivot is supplied with ball bearings and has practically no friction.



THE PULFRICH SEXTANT

The arm with its appurtenances, clamping screw, vernier, shade glasses, etc., which are not shown, is accurately balanced about the pivot, so that the instrument, which is weighted, always hangs in precisely the same position. There is a spring (not shown), worked by the pressure of a finger, which clamps the sector so that it cannot oscillate, and at the same time removes all pressure from the ball bearings. The graduations, for equal arc, are twice as many as in the ordinary instrument, for here a quadrant is a quadrant and not an octant. The prism serves as a collimator. The rays of a star pass

partly through the prism and partly through clear air, so that it is possible by adjusting the area blocked by the prism to have the direct and reflected images of equal brightness.

As the instrument pendulates, the direct image moves one way and the reflected image the other way, but twice as far. By a touch of the finger, it is easily possible to bring the pendulation to a stop momentarily, and this momentary coincidence of the two images gives us our measurement. Even with a slight movement, it is easy to judge when the excursions of the reflected image, above and below the direct image, are equal, and this gives us our point. There is no such thing as "Dip" to be corrected for, and there are conditions of the atmosphere, resulting in an abnormal refraction of the horizon line, when the readings by this instrument will be more accurate than by the ordinary sextant. The radius of the sector is about 4 inches and the whole instrument weighs less than a pound.

Before Dr. Pulfrich was satisfied with his product he tested it out thoroughly at sea on a war ship and thereafter they were supplied to airships and to the navy. During the present war, without doubt, every Zeppelin carried one or more of these instruments.

I visited the Zeiss works in 1908 and again in 1911. During the latter visit, I was easily able to confirm what Dr. Pulfrich had previously told me, viz., that it was possible with this instrument to measure an altitude accurately to one minute of arc. This is all that is required for accurate navigation. The manipulation of the instrument is as easily acquired as that of an ordinary sextant.

The present interest in the instrument lies in the fact that we are now entering upon an era when trans-ocean voyages in airships will undoubtedly become matters of routine, and navigation will have to be done with Pulfrich sextants. Certain portions of the ocean are habitually covered with low-lying fogs, but the airship sails over these and for the greater part of the time, both day and night, sights will be obtainable.

The instrument will be a boon to explorers enabling them to lighten their impedimenta by dispensing with heavy flasks of mercury troughs, etc., hitherto necessary for artificial horizons. It is possible that they may be adopted on surface ships, and night navigation, hitherto impossible, may become a routine procedure. But sea-faring men are proverbially conservative, and it will probably be many years before they can be induced to take up the "new-fangled" thing.

SOUTHERN CELESTIAL OBJECTS FOR SMALL TELESCOPES.

BERNARD THOMAS.

The wonderful southern objects mentioned in these notes are for the most part easily found with the aid of a good star map. Norton's excellent maps answer well. However, I have defined the constellations as in Gould, so there is sometimes a little difference as to which neighboring asterism a certain object belongs to. That, however, is a small matter, as the right ascension (R. A.) and declination (Dec.) for 1900 are added. Brief notes are added as to the magnitude and spectrum, when known, of the brighter stars. In this case the Harvard notation, as being the best and most scientific, is adopted.

When possible the distance of the stars, as noted by their parallax (π) and distance in light years (L. Y.), is added. Of interest too is the sun power (S. P.) and absolute or real magnitude (A. M.) These particulars have been obtained from Heath's little book just published. The information obtained has been derived from a variety of sources. I may specially mention notes supplied by Mr. H. C. McKay of Melbourne; Measures of double stars by Mr. Innes of Johannesburg and also his reference catalogue of double stars. Dreyer's New General Catalogue (N.G.C.) of Nebulae and star clusters has also been drawn on and a variety of other sources, including that culled from POPULAR ASTRONOMY and the English Mechanic, not forgetting Webb and Smythe. To all these and others I owe much. The various objects have been grouped by constellations, arranged alphabetically. In the case of double stars the magnitude is followed by the position angle and then the distance.

Abbreviations: y, yellow; b, blue; w, white; ysh, yellowish; blsh, bluish; N, north; S, south; pr, preceding; f, following; U. A., after a number, Gould's number; H, Sir John Herschel; R, Russell; I, Innes; Δ, Dunlop Catalogue of Double stars or Nebulae; N. G. C. New General Catalogue of Nebulae and Clusters; Lac, Lacaille; Lal, Lalande; m, magnitude; O, B, A, F, G, K, M, followed by letter or number, spectral class; pm, proper motion per year; cpm, common proper motion; "Fixed" after a double star indicates little or no relative motion since first measured. Bin, binary; P, period; a, semi-axis major; T, date of periastron; M, mass compared to sun's; A. U., distance in terms of sun's distance from earth; π, par-

allax; L. Y., light years; A. M., absolute magnitude; S. P., luminosity; S. M., sun's magnitude at distance of star.

Antlia.

An obscure constellation between *Hydra* and *Vela* containing few objects of interest.

α *Antliae*; $10^h\ 22^m.6$, — 30° 34′. Magnitude 4.23. Spect. K5.

ξ^1 *Antliae*; $9^h\ 26^m.5$, — 31° 27′. A fine double star: 5.7, 6.5; 210°.5, 8″.49. Scott 1898. Fixed. y. blsh. Forming triangle with two 8m stars. ξ^2 *Antliae* in field, 7½′ distant.

h 4224; $9^h\ 31^m.7$, —30° 47′. Mag. 7.9. A little N f small double: 8.1, 9.2; 116°.6; 7″.33 (1896).

S *Antliae*; $9^h\ 27^m.9$, — 28° 11′. Variable with shortest period known (1918) apart from cluster variables. Mag. 6.7 to 7.8. Period $4^h\ 47^m$.

δ *Antliae* $10^h\ 25^m.0$, — 30° 06′. Mag. 5.8. Double: 5.8, 9.2; 226°.2; 11″.3 (See 1897). Fixed.

U *Antliae* (71 U. A.); $10^h\ 30^m.8$, — 39° 03′. Mag. 5.8 (Gould); brilliant red; has changed from 7^m. —γ *Antliae* formerly 5 mag., now 7 in Lacaille's time.

Apus.

Another very small constellation, the principal stars of which, with δ and ρ *Octantis*, form a little sickle not unlike, in minature scale, that in *Leo*. No star above third magnitude. α *Apodis* is magnitude 3.81. δ *Apodis*, which is 1° following γ, makes a beautiful wide pair, δ^1 mag. 4.73, Mb, and δ^2 mag. 5.19: 4.7, 5.2; 12°.9, 102″.3 (1872).

θ *Apodis*; $13^h\ 35^m.6$, — 76° 19′. Mag. 5.64. Suspected variable 5½ to 6½.

h 4671; $14^h\ 17^m.1$, — 79° 39′. Mag. 7.5. In low power field with ε *Apodis*; a minute double: 7.9, 8.5; 127°.6, 4″.48 (1914). Fixed.

R *Apodis*; $14^h\ 46^m.5$, — 76° 15′. Mag. 5.37, variable, irregular, to 6 magnitude.

β *Apodis*; $16^h\ 28^m8$, — 77° 19′. Mag. 4.16. K. pm 0″.452 to 220°.0. Radial velocity — 27.7 kms. (cp α *Centauri*, γ^2 *Normae*, ξ *Telescopia*, δ *Pavonis*, φ *Pavonis*.) Has a distant 7^m companion.

h 4904; $16^h\ 56^m.9$, — 75° 15′. Mag. 7.4. Double. 7.7, 9.0; 187°.0, 7″.07 (Innes 1901).

Dunlop 214 (Lac 7107); $17^h\ 03^m.1$, — 67° 04′. Mag. 5.94. K5; pm 0″.196 to 241°.8. 6.0, 8.4; 344°.3; 27″.1 (1880). In motion, pm. Is N pr. ζ *Apodis*.

N. G. C. 6362 (Δ 225); $17^h\ 21^m.5$, — 66° 58′. Follows the above. Globular cluster. Stars 14^m — 16^m. Bright and large.

Ara.

Ara, the Altar; not a large constellation, but contains some bright stars. Principal stars arranged in two parallel lines running north and south. In the Milky Way.

h 4866 (Lac 6887); $16^h\ 31^m.4$, —56° 48′ On border of *Norma*: 7.9, 8.3; 124°.9; 3″.46 (1913). Probably fixed. Both yellow. Many stars in field.

Nova 1910; 16h 33m.1, — 52° 14′. From 6.0.

N. G. C. 6193 (Δ413); 16h 34m, — 48° 33′. A fine cluster north of the next objects, which form part of it.

h 4876 16h 33m.8, — 48° 35′. Mag. 5.6. A fine double star; both yellow; in large instruments quadruple, with two distant 9 mag. comites: 6.1. 7.1; 266°.1; 9″.53 (1897 Cape). Fixed. Also 9.5, 12.1; —11°.6; 1″.73 —180°; 9″ est. 1896.

N. G. C. 6204 (Δ442); 16h 40m.6, —46° 50′. A small cluster closely followed by a triple: 7, 9, 8 (7, 8; 309°.2; 55″.3). The center star a close double 9, 10, est. 6″.

h 4885; 16h 40m.1, — 48° 10′. Follows 6193. Mag. 7.8: 8.2, 9.1; 242°.7; 4″.24 (1897), — 7.7 is 45″ Nf; 7.0 a little Npr.

N. G. C. 6200 16h 36m.8, — 47° 17′. Cluster in Milky Way.

Cordoba 47 (Lac 6982); 16h 43m.0, —49° 52′. Mag. 6.55, Spect. A. A little pr 24 U. A. (ρ^2), on line to γ^2 *Normae*. No change since 1835: 7.3, 7.3; 48°.6; 2″.35.

N. G. C. 6208 (Δ 364); 16h 43m.5, — 53° 38′. Cluster, 8-11 mag.

h 4890; 16h 46m.4, — 46° 13′. Small, wide: 8, 9; 144°.2; 31.″4; preceded by 9m; rich field.

Cordoba 48 (*Lac 7075*); 16h 55m.2, —50°, 0′.1. Is 1° N of ρ^2. Mag. 7.0: 7.5, 8.2; 234°.6, 8″.00 (1902 Innes). In motion; distance and angle increasing.

Dunlop 213 (*Lac7141*); 17h 2m.9, —46° 37′. Mag. 6.98: 7.2, 8.7; 167°.4; 7″.82 (1913). Fixed. A fine object in a good field.

N. G. C. 6326; 17h 12m.8, — 51° 39′. Globular cluster.

γ *Arae*: 17h 17m.0, —56° 17′. Mag. 3.51, B1. pm 0″.028 to 248°.8. Has 11m at 28″; double in field: 8, 10, 20″; also two pairs follow: 3.5, 11 at 28″, and 11.4; 328°.6; 18″.6 (See 1897). Difficult objects for small telescopes.

β *Arae* 17h 17m.0, — 55° 28′. Mag. 2.8, Spect. K2, is 51′ south of γ. Fine naked eye pair.

h 4949 (P XVII 73); 17h 19m.5, —45° 45′. Mag. 5.55, B9. Slow binary, showing decrease of angle: 6.0, 6.8; 261°.2; 2″.69 (1913); (267°.4, 3″.23 h 1836. 7.4 is 2′ Npr.)

α *Arae* 17h 24m.2, — 43° 48′. Mag. 2.86, B5p.

κ^1 *Arae*; 17h 18m.2, — 50° 33′. Mag. 5.3; 5.3, 9.7; 159°.4; 76″.1. In field with κ^2, Mag. 6.5. [The 9.7 is a very close double in large telescopes: 10, 11; 274°.7, 4″.69 (1900).]

N. G.C. 6397 (Δ 366): 17h 32m.5, — 53° 36′. One of finest globular clusters visible to naked eye; stars 13m; Nf π *Arae*.

R 303; 17h 36m.9, — 54° 05′. Mag. 7.6; is a neat double. Sf this fine cluster: 7.8, 9.0; 111°.2, 3″.49 (1913).

Glenorchy, Tasmania.

RESPECTING A POSSIBLE DESTRUCTION OF HUMAN LIFE.

CHARLES NEVERS HOLMES.

The surface area of our world contains about 197,000,000 square miles. Upon this broad surface area, consisting of water and land, there dwells at present a population approximating 1,700,000,000. If we divide the present terrestrial population by our earth's surface area, we obtain what would be the average population for each square mile—about 9 human beings. Now more than one-and-a-half billion of divers sorts of people seems a very large number, but, is, nevertheless, a very small number compared with the *total* population of our globe, living and dead. Yet 1,700,000,000 people would certainly be a huge concourse assembled in one place—allowing four square feet to each of them, such a place would cover about 244 square miles—and it is interesting to consider, apart from personal danger, if there be any possibility of their destruction or the destruction of succeeding generations by some unexpected accident to the earth.

As far as we know, there will—in our generation at least—be no such unexpected accident to the earth. Between our planet and the nearest calculated sun of night there is a stupendous gulf of space, across which that sun's rays reach our world after a long journey of 4⅓ years. And supposing that *Alpha Centauri* is travelling towards our solar system with a velocity of 13-14 miles per second, even were our system to stand still and *Alpha Centauri* to continue such a course, it would be approximately 600 centuries before the then inhabitants of the earth would be in danger of destruction. It will in all probability be found that other suns are nearer us than is *Alpha* of the constellation of *Centaurus*, but it does not seem possible that any sun of night will collide with our planet, during our own generation. With respect to succeeding generations it may be that some foreign sun will destroy all the world's population, and such a sun might accomplish this without actually striking the earth.

It is well-known that a planet shines by reflecting the sun's light and that were it situated sufficiently far away from the sun it would be invisible to us. Therefore, in the space outside of our solar system there may exist a vast number of such invisible bodies, and one or more of them may be closer to us than we are aware. But were any of them of considerable size it would be much further away than is

Neptune, the farthest off of our planets, for otherwise its presence would be revealed by the illuminating rays from our sun to the powerful eye of some telescope. But Neptune is only about 2,700,000,000 miles distant, and a planet of the same size as the earth might be within 100,000,000,000 miles of the solar system, rushing straight towards us, and its dangerous presence not be discovered. If a body like this were speeding with a velocity of 100 miles per second it would reach us in about 33 years, provided other conditions were just right, so that it is *possible* that some of us living here today may perish in a collision with such a foreign planet.

Indeed, it may be that our world will be destroyed by the invasion of what was formerly another solar system, now in utter darkness because its sun has cooled and cannot illuminate the surrounding satellites. Such a "dead" sun and its system would be very disastrous to encounter, particularly if the cool sun were a huge one and if the rest of the system consisted of many large planets extending over billions of miles. But the near approach of such a system would certainly be announced and discovered by irregularities in Neptune's orbit, although it is possible that these irregularities might at first be attributed to the presence of another planet in our own solar system, situated at a greater distance than Neptune. It seems certain that were our own system, speeding into space about 12 miles per second, to collide with another system of the same size and travelling with the same velocity, an extensive destruction would ensue. Were this meeting what is known as a "head on" collision the chances would be very minute that any human being would be left alive to "tell the tale." It is true that the intruding system would be a "dead" one but the resulting impacts between swiftly moving bodies, drawn together by the powerful force of gravity, would quickly revive these clashing planets to fiery existence. And when this collision was over how would our solar system appear in interstellar space? In all probability the sun would be blazing with terrific fury and one or more of its satellites shattered beyond recognition. The orbits of surviving planets, as well as the fragments of any that were shattered, would be changed in a greater or lesser degree. And respecting our own little planet-home?—almost anything may be imagined—its atmosphere mostly disappeared, its vegetation burned to dust, its internal fires pouring out through big cracks in its surface, and its human life and civilization cremated and destroyed!

It is also possible that something else besides suns and satellites might exterminate all human life. Man has ceased to dread the approach of comets, despite their weird appearance; yet it may be that sometime one of these spectres of the sky, having perhaps considerable density

and containing larger particles, will collide with the earth, causing both terror and tragedy. Then, it is possible that such a colliding comet may be associated with poisonous gases which might kill thousands and thousands of people. We all are well aware that even good-sized meteors have fallen to the earth's surface, and from this sudden source there is always, day or night, a chance of destruction to human life. Moreover, our planet, as it speeds amid space in company with the rest of the solar system, may pass through conditions and substances in the ether, whose existence is not yet known to astronomical science. For example there may exist in sidereal space vast extents of poisonous or inflammable gases.

Occasionally a new star will blaze out suddenly in the darkened firmament and then gradually fade away. The cause for this increase in brightness has not yet been satisfactorily explained. Of course it may occur from collisions of huge solar systems or from collisions of vast suns. But why should it not be caused by some sun encountering in space a wide extent of inflammable gas or gases? In such a case a fiery sun would instantly ignite these inflammable gases, thus suddenly increasing its apparent brightness. Even with the most powerful telescope it would be impossible to see the burning gases around the "new star", owing to the remoteness, and it would seem as though the star had merely increased in brilliancy. If this is so, then it would be possible for our own sun to enter and ignite such a region of inflammable gases whose heat would probably soon destroy all human life upon a planet as near the sun as is the earth, provided that all human life were not already destroyed by the presence of the gases themselves. And should our solar system happen to pass through a nebula, in some future age, it appears certain that all human life would immediately perish.

It does not seem in the least probable that all people upon earth will be destroyed by unexpected internal terrestrial action or by any action originating *within* the solar system. We are situated too far from the sun for any convulsions upon his fiery surface to exterminate mankind, and, although we cannot be absolutely certain, it does not appear possible that a sudden solar explosion will, now or later, destroy every human being, either directly by that explosion or indirectly because the sun's heat ceases to reach our planet. Nor does it seem possible that any unexpected disaster can happen to the other planets, to the moon, or to our world, from interior conditions. With respect to an explosion of our earth, caused by gases in its interior or by other means, this is in all probability impossible, since the terrestrial interior contains wholly more or less dense molten substance or substances. It is true that volcanic eruptions and earthquakes have slain thousands

and thousands of people but these are and will continue to be merely local tragedies.

Nevertheless, because our world has not hitherto, as far as we know, collided with fiery or "dead" sun, or with foreign planet, or passed through regions in space containing poisonous and inflammable gases we should not feel wholly secure from such disasters. On the other hand, there is the strongest probability that we of the present generation shall die, *most* of us, a natural death. With regard to future generations, let us say—*Quien sabe*? It may be that some fate is in store for us of which we, with our present scientific knowledge, cannot either know or dream.

Newton, Mass.
41 Arlington St.

NOTE ON THE COLOR OF NOVA AQUILAE III.

E. E. BARNARD.

Since its advent in the morning sky, this star has presented an extremely beautiful appearance in the large telescope. It has been of an exquisite blue color, wholly unmatched by any other star in the sky.

This was specially remarkable in March. The out-of-focus image no longer contained any trace of red; it was entirely blue with a darker blue center. In the proper focus the image was unlike that of the ordinary star, and larger, but not a clean-cut planetary disc as it was in the autumn, before conjunction with the sun. On June 5 it was roughly 1″.4 in diameter. As the nova has faded this blue has become very much weakened and the star is now pale white, very closely bordered with strong blue, as if it were a white star shining through a blue envelope. In a 4-inch telescope the nova is now about 7th magnitude.

I have given an account of other peculiarities of the nova in the Astrophysical Journal for April 1919, Vol. 49, p. 199.

Yerkes Observatory,
Williams Bay, Wisconsin.
June 10, 1919.

A NEW TRANSIT REDUCTION COMPUTING MACHINE.*

EDWARD C. PHILLIPS, S. J.

I. Introductory.

The instrumental correction which must be applied to the observed time of transit of a star or other celestial object over the mean thread of a transit or meridian circle instrument is given conveniently by Mayer's Formula as follows:

$$\tau = a \sin(\phi - \delta) \sec \delta + b \cos(\phi - \delta) \sec \delta + c \sec \delta$$

where

τ = total instrumental correction
a = azimuth constant of instrument
b = level constant of instrument
c = collimation constant of instrument
ϕ = latitude of the observer
δ = declination of the star

This formula is frequently written in the abridged form

$$\tau = aA + bB + cC.$$

The actual calculation of this correction is usually carried out by means of logarithms or of numerical tables specially prepared for this purpose. These numerical tables give the "Transit Factors" A, B, C, for successive values of the declination differing by convenient intervals determined according to a degree of accuracy desired in the calculations. After the tables have been prepared for a given latitude it is necessary to find from them by interpolation the values of A, B, C for the given star; these values of the Factors are then multiplied, usually with the help of Crelle's or similar tables, into the respective instrumental constants a, b, c; the proper algebraic sign is prefixed to each product and finally the algebraic sum of the three products is taken to give the total correction. The purpose of the device described in this paper is to obtain mechanically the value of τ, thus rendering unnecessary the preparation of any tables or the use of any numerical calculations whatever. It is believed that a considerable saving of time and labor will be thus secured without the sacrifice of the required degree of accuracy in the results.

* Read at the Twenty-Second Annual Meeting of the American Astronomical Society, Cambridge, Mass., August 20, 1918.

In the following sections only the essential features of the instrument are given, unnecessary details of construction and adjustment being omitted.

II. Construction of the Calculator.

Figure 1 is a photographic reproduction of the model of the device which was presented at the meeting of the Astronomical Society.

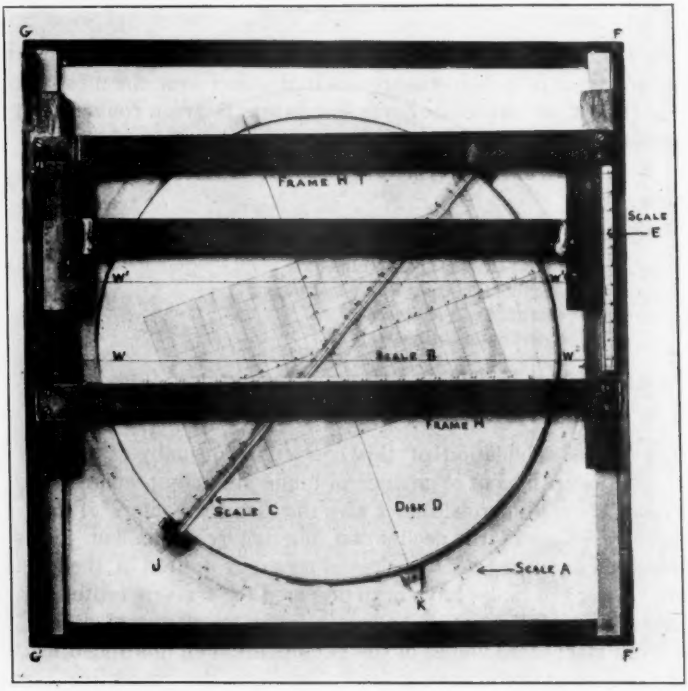


Figure 1. A New Transit Computing Machine.

There are three essential parts:

1) A rectangular base GF′, Figure 1, on which is engraved a divided circle designated as Scale A; this base also has two guides or runways FF′ and GG′, parallel to the zero diameter of circle A.

2) A disk D rotating on an axis concentric with the divided circle A. On this disk is engraved a cross-section ruling or ordinary system of rectangular coördinates, designated in the figure as Scale B; and also a linear scale C along the diameter of the disk, this diameter making with the vertical axis of the cross-section ruling B an angle

equal to the latitude of the place of observation. The origin of the cross-section ruling B and the zero of the radial scale C both coincide with the center of the disk, and the unit of measure is the same for both scales. Scale C is numbered in both directions from the center. There is an index or marker J attached to the extremity of the scale C and another index K is attached to the extremity of the vertical axis of the scale B; these indices or markers allow us to read the angle through which the disk is turned.

3) A rectangular frame H carrying two parallel lines (wires), W and W′, which may be adjusted at any desired distance apart, there being on one edge of the frame a scale E having the same unit of measure as scales B and C and serving to measure the distance between the two lines W and W′. This frame itself slides in the guides FF′ and GG′ attached to the sides of the base of the instrument, so that the two lines W and W′ whilst keeping their relative distance unaltered may be moved at will in a plane parallel to the surface of the disk. The wires are adjusted so as to be perpendicular to the zero diameter of the scale A and at such a level that they just graze the surface of D, thus eliminating parallax between the lines W, W′ and the scales B and C.

III. Operation of the Calculator.

To obtain by means of the machine the value of the instrumental correction for any given observation the following four steps are required:

1) Adjust the lines W and W′ at a distance apart equal to the collimation constant *c*.

2) Rotate the disk D until the index J reads the declination of the star, or the index K reads the zenith distance.

3) Slide the frame H until the line W passses through the point whose coördinates on scale B are (*a*, *b*), i.e., the azimuth and level constants respectively of the transit instrument. The azimuth coördinate is taken along the horizontal axis of the scale B and the level coördinate along the vertical axis.

4) Note the reading of the point where the line W′ intersects the scale C; the reading of scale C at that point is the total instrumental correction sought.

N. B. The usual conventions as to algebraic signs must be observed in setting the machine and reading the scales.

IV. Theory of the Calculator.

We must show that when the device has been set according to the instructions given in the preceding section the line W′ will cut the

radial scale C at a distance from the origin equal to the total instrumental correction.

For the sake of clearness we give in Figure 2 a simple diagram of the instrument set for correcting a particular observation: only those lines are indicated which are necessary for the proof, the full lines

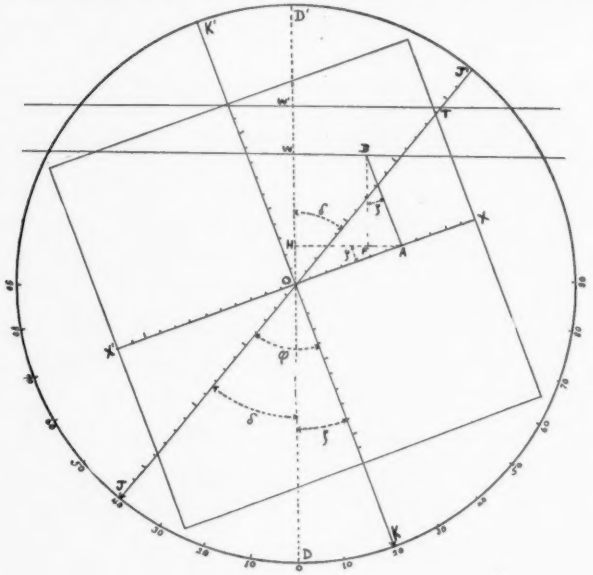


FIGURE 2.

representing lines actually visible on the machine and the dotted lines representing constructional lines added for the geometric demonstration.

The setting represented in the figure is for the following values of of the quantities involved:

$$\phi = 60^\circ \text{ N}; \quad \delta = 40^\circ \text{ N}; \quad \zeta = (\phi - \delta) = 20^\circ \text{ S};$$
$$a = 0^{\text{u}}.7; \quad b = 0^{\text{u}}.6; \quad c = 0^{\text{u}}.3.$$

In the figure

XX′ and KK′ are the axes of the rectangular coördinate system of scale B

JJ′ is the radial scale C

WB and W′T are the parallel lines W and W′

DD′ is the zero diameter of the graduated circle A

B is the point whose coördinates are (a, b) and through which the line W is made to pass

T is the intersection of the line W′ and the radial scale C

From A, the foot of the ordinate of the point B, drop a perpendicular on DD meeting it in H

From B drop a perpendicular on AH meeting it in F

Since by supposition we have rotated the disk D with its scales B and C until the line JJ′ makes an angle δ with the axis DD′ and the line KK′ makes an angle $\phi - \delta$ or ζ with the same axis DD′, it will be easily seen from the construction indicated above that angles OAH and ABF are each equal to DOK, the zenith distance of the star. Also that OA equals a, and AB equals b, and WW′ equals c.

Hence we have:

$$\begin{aligned} OH &= OA \sin OAH = a \sin \zeta \\ HW &= FB = AB \cos ABF = b \cos \zeta \\ WW' &= c \end{aligned}$$

And by addition

$$OW' = a \sin \zeta + b \cos \zeta + c$$

But angle D′OJ′ equals DOJ or δ; hence

$$OT = OW' \sec \delta = a \sin \zeta \sec \delta + b \cos \zeta \sec \delta + c \sec \delta,$$

the total instrumental correction required.

Figure 2 has been constructed for the case where all the quantities involved are positive, but the demonstration holds good no matter what may be the signs of the constants or the size of the angles. A consideration of the device as shown in Figure 1 will readily make it clear that the sign of the azimuth correction changes when the index K of the rotating disk passes through 0°, i.e., when we pass from South Zenith Distance to North Zenith Distance, whilst the sign of all the corrections changes when the index J of the disk passes though 90°, i. e., when we pass from a star culminating south of the Celestial Pole to one culminating north of it. Hence the calculator gives the instrumental correction with its proper magnitude and algebraic sign for all positions.

V. Accuracy of the Results.

When the greatest precision is required the values of the constants a, b, c are generally given to three decimals, i. e., to thousandth of a second of time; owing however to observational difficulties and the lack of absolute stability in the transit instrument itself, the third decimal place in these constants is in doubt by at least two or three units and often by four or five units; hence also the resulting value of the calculated instrumental correction is in doubt by at least the same amount for equatorial stars and to an increasingly greater extent for increasing values of the declination. If we consider τ, the instrumental correction, as a function of the three independent variables a, b, c and calculate the value of its total differential at different declinations when da, db, dc are each made equal to $0^s.002$ the result will give us the effect produced on τ by an error of $0^s.002$ in each of the constants.

Supposing the errors to be cumulative and the absolute values of a, b, c to be unity, we find that at latitude 0° these errors in a, b, c produce in τ the errors tabulated in the third column, Table I; for latitude 40° N the corresponding errors are given in the fifth column. From this it follows that the actual uncertainty in τ is at least a few thousandths of a second for equatorial stars and increases with the declination at about the same rate as the secant of the declination.

Hence we conclude that a mechanical device for computing τ is sufficiently accurate for precision work provided the resulting value given by the machine is easily obtained to within the same degree of accuracy as just indicated above.

TABLE I.

δ °	sec δ	$\Delta\tau$ for $\phi = 0°$	Er. of machine $\phi = 0°$	$\Delta\tau$ for $\phi = 40°$ N	Er. of machine $\phi = 40°$ N
0	1.000	0.004	0.002	0.005	0.003
10	1.015	0.004	0.002	0.005	0.003
20	1.064	0.005	0.003	0.005	0.003
30	1.155	0.006	0.004	0.005	0.003
40	1.305	0.006	0.004	0.005	0.004
50	1.556	0.008	0.005	0.007	0.005
60	2.000	0.009	0.007	0.009	0.008
70	2.924	0.011	0.011	0.014	0.014
80	5.759	0.025	0.029	0.027	0.039
90	inf.	inf.	inf.	inf.	inf.

The working model of the device herewith presented (Figure 1) has a divided circle 14 inches in diameter, its smallest divisions being equal to 15′ and allowing us to set by estimation closely to within 1′ for declination and zenith distance: the unit of the coördinate system B and of the scale C is one-twentieth (1/20) of an inch, each unit representing 0ˢ.01, so that we can set and read by estimation very closely to within 0ˢ.001. The cumulative effect on the value of τ produced by an error of 1′ in declination and 1′ in zenith distance along with an error of 0ˢ.001 in setting for each of the constants a, b, c is given in Table I, fourth column, for 0° latitude and in the sixth column for 40° N latitude. Comparing these errors of setting with the actual observational uncertainty in τ given in the third and fifth columns, we see that for non-circumpolar stars the mechanical method of determining the instrumental correction is *theoretically* quite accurate enough even for precision work.

For circumpolar stars the direct mechanical method breaks down as is usually the case, with graphical methods, when the secant of large angles is involved; but even for such stars the other factor of the correction, namely $a \sin \zeta + b \cos \zeta + c$, can be determined by the machine with as much accuracy as for equatorial stars, and a single multiplication by the natural secant of δ will give the desired result to the necessary degree of accuracy even for Polaris.

We stated above that the mechanical method is *theoretically* accurate enough for precision work; is it also *practically* accurate enough? The best way to arrive at the answer to this question is to have a good machine made and test its results with the values of the corrections obtained by the usual numerical computation. The model represented in Figure 1 was tested in this manner and the results are surprisingly accurate when we consider that the model is rather imperfectly constructed out of inferior materials.

The following table gives the errors of the machine for a hundred corrections for stars of 60° or less in declination; the latitude of observation was about 40° N, and the absolute values of the instrumental constants varied from about 0ˢ.9 to 0ˢ.2.

TABLE II.

Magnitude of error	No. of times occurring with + sign	No. of times occurring with − sign	Sum of errors with + sign	Sum of errors with − sign
ˢ				
0.006	0	1	0.000	0.006
0.005	0	2	0.000	0.010
0.004	3	7	0.012	0.028
0.003	2	13	0.006	0.039
0.002	11	9	0.022	0.018
0.001	15	23	0.015	0.023
0.000	14		0.000	0.000
Totals	31	55	0.055	0.124
Arithmetical sum	100		0ˢ.179	

Average error of machine 0ˢ.0018.

The preponderance of negative errors seems to indicate the presence of a systematic error due to some mechanical imperfection of the model; with a properly constructed machine we may expect the average error to be reduced to 0ˢ.001 or less. Moreover since even in precision work the third decimal is finally discarded in the adopted values of the instrumental corrections, and since ninety-seven per cent of the errors of the machine occurring in the above test are less than 0ˢ.005 we may safely conclude that the accuracy of the mechanical method here described is amply sufficient for the present requirements of the astronomer.

VI. Some Other Applications of the Apparatus.

The apparatus was originally devised for the evaluation of Mayer's formula, but it can easily be employed for other calculations both arithmetical and trigonometrical; such, for example, as multiplication and division of arithmetical numbers and also of quantities involving arithmetical numbers and various trigonometrical functions of one or two angles, transformation of rectangular coördinates, etc. We shall

here indicate briefly in some detail only one such application.

In many observatories transit observations are reduced by Bessel's formula, which is more convenient than Mayer's when there are a number of reductions to be made for the same values of the constants a and b. This formula is:

$$\tau = m + n \tan \delta + c \sec \delta.$$

Now if in Mayer's formula we put $\phi = 0$, or, what is equivalent to this, if we make $\zeta = -\delta$, we get:

$$\tau = -a \sin \delta \sec \delta + b \cos \delta \sec \delta + c \sec \delta$$

or

$$\tau = -a \tan \delta + b + c \sec \delta$$

which is of the same functional form as Bessel's formula.

But to make $\phi = 0$ is mechanically equivalent to making the radial scale C of the computing device coincident with the vertical axis of the coördinate system B; in other words if we use Bessel's formula for transit reductions we can dispense entirely with the radial scale C and the apparatus is thus materially simplified.

Woodstock College; Woodstock, Md.

THE ANNULAR ECLIPSE OF THE SUN OF 1919 NOVEMBER 22 AS VISIBLE IN THE UNITED STATES.

WILLIAM F. RIGGE.

Except in the Pacific states, the annular eclipse of the sun of 1919 November 22 will be visible to a greater or less extent all over the United States. The accompanying maps will probably give us all the details that we may need for its observation.

Figure 1 is for the beginning of the eclipse. The curve marked "Eclipse begins at Sunrise" is almost self-explanatory. It means that to the east of it the eclipse begins a short time after the sun rises while to the west of it the sun will rise eclipsed to the percentage indicated by the curves marked from 0 to 90. There is this difference, however, that to the east of the line running through the Mississippi valley, which in the next map is marked "Middle of the Eclipse at Sunrise", the eclipse will be increasing, while to the west of it the eclipse will be diminishing. The lines marked from 6:20 to 6:50 along the right border Figure 1 indicate the central times of the beginning of the eclipse, while those marked N 80 W, West, S 80 W, and S 70 W show the position angles of the point of first contact on the sun's limb counted from its north or south point, and those marked from T 10 R to T 70 R show them as reckoned from the sun's vertex or top towards the right. The lines marked 6, 7, 8, 9, on the upper border show the full hours of the central times at sunrise.

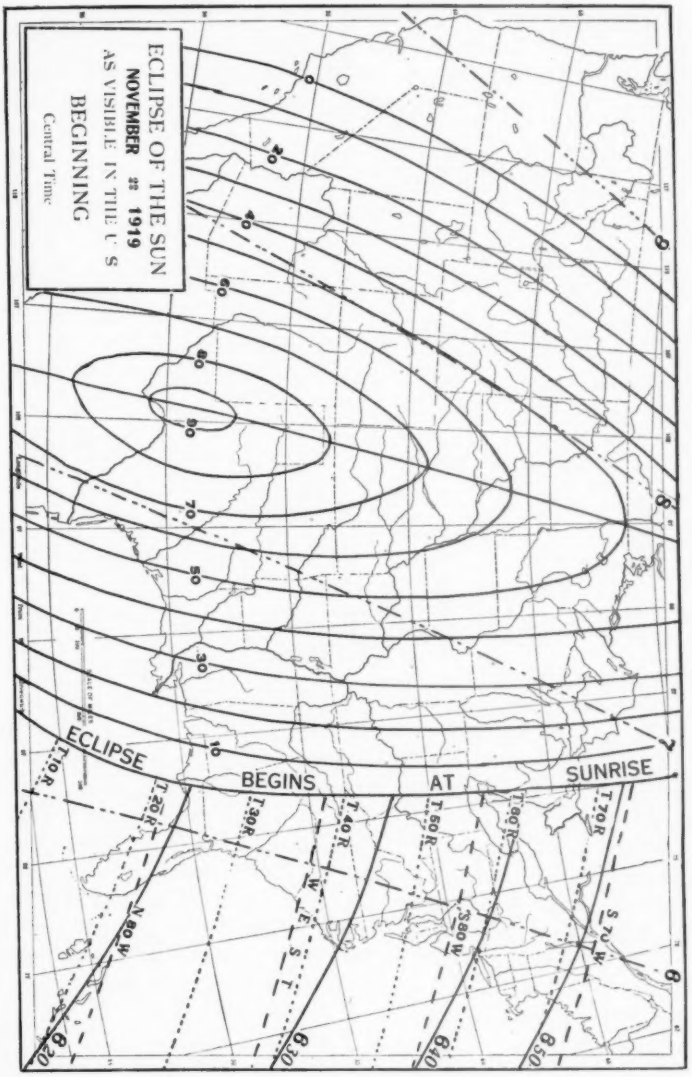

ECLIPSE OF THE SUN
NOVEMBER 2: 1919
AS VISIBLE IN THE U. S.
BEGINNING
Central Time
ECLIPSE BEGINS AT SUNRISE
T.10 R.
T.20 R.
T.30 R.
T.40 R.
T.50 R.
T.60 R.
T.70 R.
N.80 W.
S.80 W.
S.70 W.
S.60 W.
6.20
6.30
6.40
6.50
0
10
20
30
40
50
60
70
80
90

FIGURE 1.

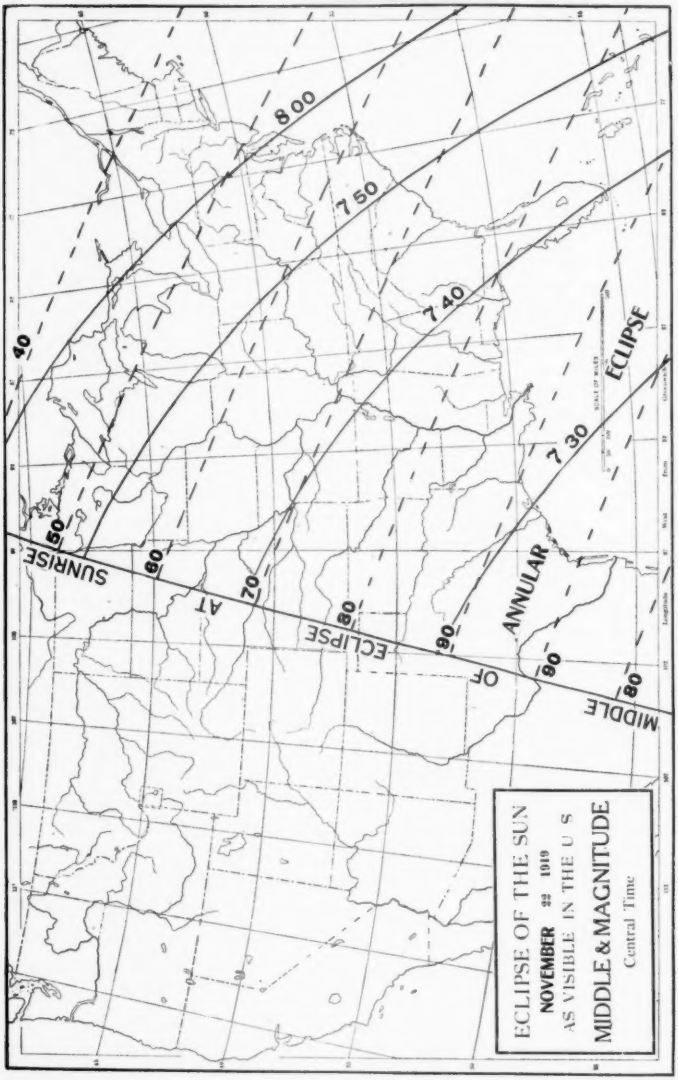

8 00
7 50
7 40
7 30
40
50
60
70
80
90
SUNRISE
AT
ECLIPSE
OF
MIDDLE
ANNULAR
ECLIPSE
ECLIPSE OF THE SUN
NOVEMBER 22 1919
AS VISIBLE IN THE U S
MIDDLE & MAGNITUDE
Central Time

FIGURE 2.

Figure 2 is for the middle of the eclipse, the numbers from 7:30 to 8:00 giving the times when the obscuration is a maximum, and those from 40 to 90 showing its per cent. The path marked "Annular Eclipse" is bounded by the 90 per cent lines, thereby showing that everywhere within this belt the obscuration is 90 per cent.

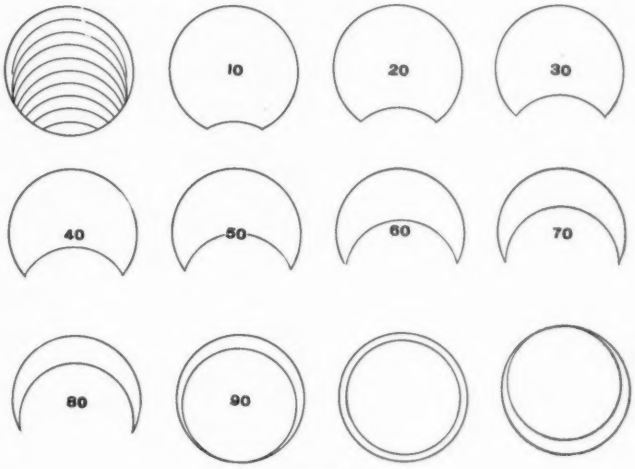


FIGURE 3.

Figure 3 gives the appearances of the sun for every ten per cent of obscuration. The second figure from the end shows the sun with the moon placed centrally before it, as it will appear on the central line of the annulus path, while the figures on either side show the internal contacts as well as the grazing contacts on the borders of the annulus path. The annulus in this eclipse has very nearly its greatest possible width, the semidiameters of the sun and moon being respectively 16′ 11″.7 and 14′ 41″.3 while the maximum semidiameter of the sun is 16′ 16″.0 and the minimum semidiameter of the moon is 14′ 40″.8, according to Buchanan in his Theory of Eclipses, page 29.

Figure 4 gives the data for the end of the eclipse. The full lines marked at the bottom from 8:40 to 9:20 give the times, while the broken lines from S 80 E to S 40 E give the position angles counted from the sun's south point toward the east, and the dotted lines B 20 L to B 30 L give them as reckoned from the lowermost or bottom point towards the left. West of the line "Eclipse ends at Sunrise" the eclipse will not be visible.

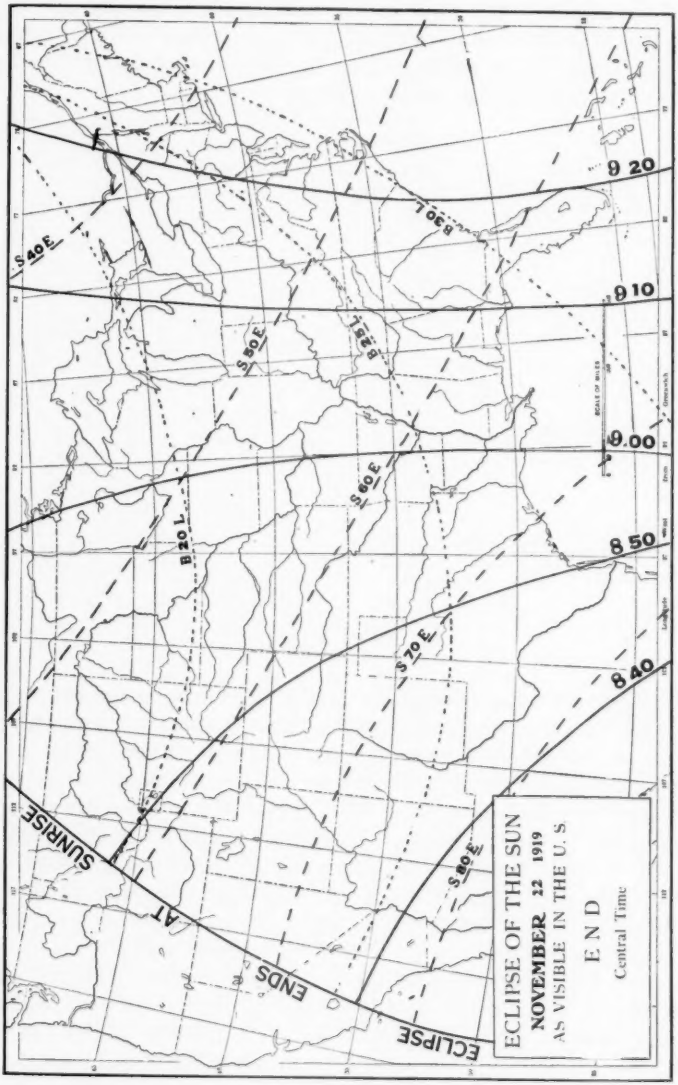
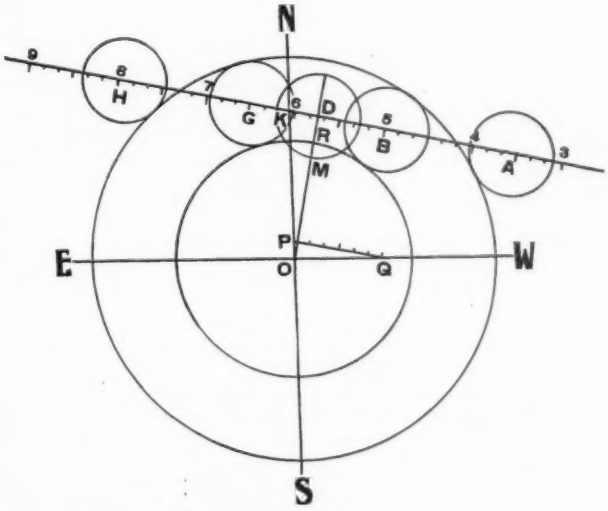

9 20
9 10
9.00
8 50
8 40
S 40E
S 50E
S 60E
S 70E
S 80E
B 30 L
B 20 L
SUNRISE AT ENDS ECLIPSE
ECLIPSE OF THE SUN
NOVEMBER 22 1919
As VISIBLE IN THE U. S.
E N D
Central Time

FIGURE 4.

PARTIAL ECLIPSE OF THE MOON 1919 NOVEMBER 7.

WILLIAM F. RIGGE.

On November 7 there will be a small eclipse of the moon, its magnitude being only 19 per cent, and even this being visible only over the eastern half of the United States. The diagram will give the particulars.

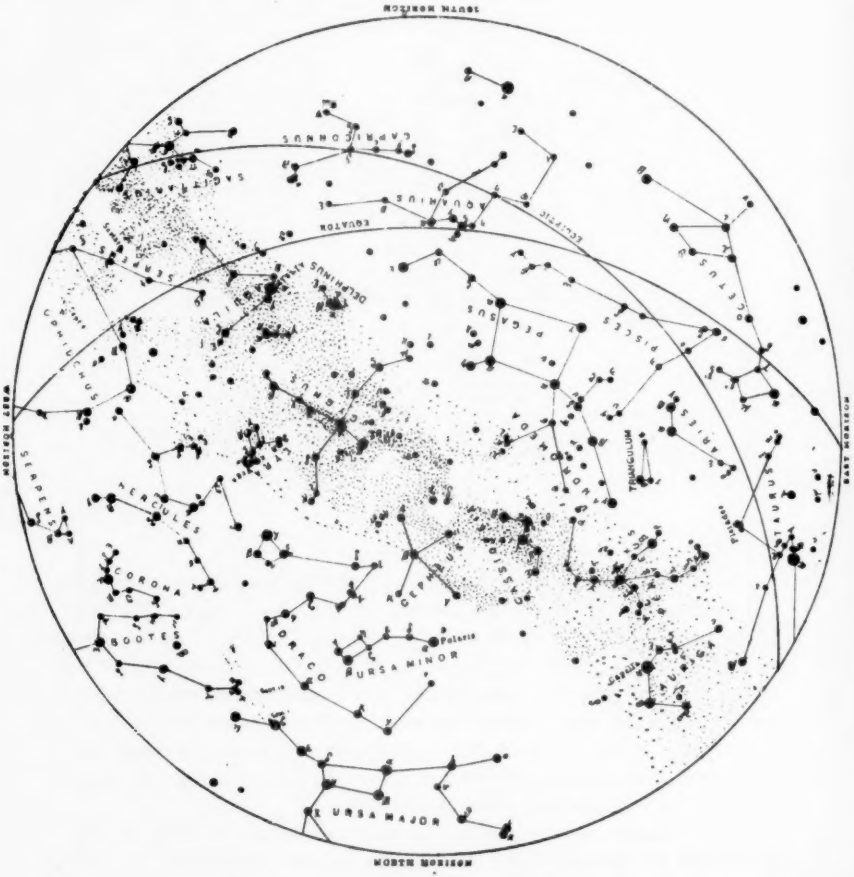


The largest circle is a cross-section of the earth's penumbra and the one next in size of the earth's shadow at the place where the moon will cross them. N S E W are the cardinal points. The five small circles are five positions of the moon at important moments. When its center is at A at 3:34 p.m. Central Time, the moon enters penumbra. At B at 4:58 the moon enters shadow. At D at 5:44 we have the middle of the eclipse, when 19 per cent only of the moon's diameter is immersed in the earth's shadow. At G at 6:30 the moon leaves shadow, and at H at 7:55 the moon leaves penumbra.

The visibility of this eclipse in the various states may be gaged somewhat by the fact that at Omaha the sun sets on that day 5:14 and the moon rises at 5:05.

PLANET NOTES FOR SEPTEMBER AND OCTOBER, 1919.

The *sun* will continue to move in a southeasterly direction during these months. At the beginning of September it will be 8° 34′ north of the equator. On September 23 it will cross the equator and on October 31 will be 13° 52′ south. The crossing of the equator will mark the time of the autumnal equinox. This will occur September 23 at 8 p. m. C.S.T. The sun will move from the constellation Leo through Virgo into the constellation Libra.



THE CONSTELLATION AT 9:00 P. M. OCTOBER 1.

The phases of the *moon* for these months are as follows:

First quarter	Sept. 2 at	8 A. M.	C.S.T.
Full moon	9 "	10 P. M.	"
Last quarter	16 "	4 P. M.	"
New moon	23 "	11 P. M.	"
First quarter	Oct. 2 at	3 A. M.	C.S.T.
Full moon	9 "	8 A. M.	"
Last quarter	15 "	11 P. M.	"
New moon	23 "	3 P. M.	"
First quarter	31 "	8 P. M.	"

The summer-time clock readings will be one hour greater for these phases.

Mercury will be at a point of greatest elongation west of the sun on September 1. At this time it will be about 6° north of the sun and will therefore rise about an hour and a half before the sun. It will be a favorable time to observe this planet. *Mercury* will then move toward the sun and pass the sun on the opposite side from the Earth on September 26. It will not be visible again during this period.

Venus because of its motion westward in the sky will be approaching the sun rapidly at the beginning of this period. It will pass between the Earth and the sun on September 12. Towards the end of October it will again appear as a morning star. It will be at a period of greatest brilliancy on October 19 at which time it will rise between two and three hours before the sun.

Mars will be in a position for early morning observation throughout this period. At the beginning of September it will rise about three hours before the sun. It will be moving eastward less rapidly than the sun and at the end of October will rise more than four hours before the sun. Mars will be approaching the Earth during these two months. It will, however, be in the neighborhood of two hundred million miles distant and will therefore not be very brilliant.

Jupiter also will be in a position for early morning observation. On September 1 its position in the sky will be very nearly the same as that of Mars. It will be moving eastward less rapidly than Mars and by the end of October it will be nearly six hours west of the sun. At the end of October it will rise a little while before midnight.

Saturn will be about two hours east of Jupiter at the beginning of September. It will just be emerging from the sun's rays and will not be far enough from the sun to be observed before the middle of October. At that time it will rise between three and four hours before the sun.

Uranus will be in favorable position during these months. It will be on the meridian on the average about 9 o'clock in the evening.

Neptune will be in the same part of the sky as Mars and Jupiter at the beginning of September. It will therefore be visible in the early morning during this period. At the end of October it will be approaching a position of quadrature 90° west of the sun.

Occultations Visible at Washington.

[From the *American Ephemeris.*]

Date 1919	Star's Name	Magnitude	IMMERSION. Washington M.T.		Angle f'm N.	EMERSION. Washington M.T.		Angle f'm N.	Duration	
			h	m	°	h	m	°	h	m
Sept. 5	267 B Sagittarii	5.8	9	46	91	11	01	226	1	15
8	51 Aquarii	5.8	16	19	40	17	10	273	0	51
16	χ^1 Orionis	4.5	10	40	81	11	30	273	0	50
16	χ^2 Orionis	4.7	14	48	137	15	37	221	0	49
18	1 Cancri	6.0	13	46	119	14	42	266	0	56
Oct. 1	21 Sagittarii	5.0	9	52	57	10	54	274	1	03
2	*d* Sagittarii	5.0	10	34	146	10	52	176	0	18
5	c^1 Capricorni	5.3	5	33	98	6	38	215	1	06
6	κ Aquarii	5.2	6	03	91	7	07	217	1	05
6	207 B Aquarii	6.3	8	19	36	9	31	264	1	12
8	51 Piscium	5.6	10	00	64	11	16	238	1	16
13	372 B Tauri	6.1	8	48	36	9	21	314	0	33
16	84 B Cancri	6.4	11	38	101	12	32	280	0	54
16	A^1 Cancri	5.5	16	24	107	17	46	293	1	21
17	ω Leonis	5.5	13	05	114	14	02	276	0	57

VARIABLE STARS.

Maxima of Variable Stars of Short Period.

[Calculated by members of the class in General Astronomy at Carleton College.]

Given to the nearest hour in Greenwich mean time. To obtain Eastern standard time subtract 5^h; Central standard time 6^h; etc. For "Summer Time" subtract 1^h less.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1919. Sept.				Oct.			
	h m	° ′		d h	d	h	d	h	d	h	d	h
SX Cassiop.	0 05.5	+54 20	8.6— 9.2	36 13.7			25	3			30	17
SY Cassiop.	0 09.8	+57 52	9.3— 9.9	4 1.7	7	9;	23	12;	9	22;	26	5
RR Ceti	1 27.0	+ 0 50	8.3— 9.0	0 13.3	5	16;	21	4;	6	15;	22	3
RW Cassiop.	1 30.7	+57 15	8.9—11.0	14 19.2	10	22;	25	17;	10	12;	25	7
V Arietis	2 09.6	+11 46	8.3— 9.0	0 23.8	9	6;	25	3;	11	0;	26	21
SU Cassiop.	2 43.0	+68 28	6.5— 7.0	1 22.8	8	11;	24	2;	9	16;	25	6
TU Persei	3 01.8	+52 49	11.4—12.2	0 14.6	4	6;	18	20;	3	10;	17	23
RW Camelop.	3 46.2	+58 21	8.2— 9.4	16 00.0	7	0;	23	0;	9	0;	25	0
SX Persei	4 10.2	+41 27	10.4—11.2	4 07.0	2	5;	19	9;	6	13	23	17
SV Persei	42.8	+42 07	8.8— 9.6	11 03.1	2	12;	24	18;	5	21;	28	3
RX Aurigae	4 54.5	+39 49	7.2— 8.1	11 15.0	8	8;	19	23,	13	6;	24	21
SX Aurigae	5 04.6	+42 02	8.0— 8.7	1 12.8	1	5;	16	13;	1	20;	17	4
SY Aurigae	05.5	+42 41	8.4— 9.5	10 03.3	10	14;	20	17;	10	24;	21	3
Y Aurigae	21.5	+42 21	8.6— 9.6	3 20.6	2	18;	18	5;	3	15;	19	2
RZ Gemin.	5 56.6	+22 15	9.1—10.0	5 12.7	4	1;	20	15;	7	5;	23	19
RS Orionis	6 16.5	+14 44	8.2— 8.9	7 13.6	7	6;	22	9;	7	12;	22	15
T Monoc.	19.8	+ 7 08	5.7— 6.8	27 00.3			19	8			16	8
RT Aurigae	23.0	+30 33	5.1— 6.0	3 17.5	4	8;	19	6;	4	4;	19	2
RZ Camelop.	23.7	+67 06	11.0—13.0	0 11.5	3	22;	18	8;	9	22;	24	8
W Gemin.	29.2	+15 24	6.7— 7.5	7 22.0	1	13;	17	9;	3	5;	19	1
ζ Gemin.	6 58.2	+20 43	3.7— 4.3	10 03.7	3	19;	24	3;	4	6;	24	14
RU Camelop.	7 10.9	+69 51	8.5— 9.8	22 06.5	5	15;	27	21;			20	4
RR Gemin.	7 15.2	+31 04	10.0—11.5	0 09.5	8	12;	16	11;	2	8;	18	5

Maxima of Variable Stars of Short Period—Continued.

Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1919. Sept.				Oct.	
	h m	° ′		d h	d h	d h	d h	d h	d h	d h
V Carinae	8 26.7	−59 47	7.4— 8.1	6 16.7	1 22;	22 0;	5 10;	18 19		
T Velorum	8 34.4	−47 01	7.6— 8.5	4 15.3	2 6;	20 20;	9 4;	27 23		
V Velorum	9 19.2	−55 32	7.5— 8.2	4 08.9	5 10;	22 21;	10 9;	27 20		
Z Leonis	9 46.4	+27 22	7.9— 9.6	59 00.0				18		
RR Leonis	10 02.1	+24 29	9.1—10.1	0 10.9	5 12;	19 2;	9 10;	23 0		
SU Draconis	11 32.2	+67 53	8.9— 9.6	0 15.8	4 17;	17 23;	7 18;	20 23		
S Muscae	12 07.4	−69 36	6.4— 7.3	9 15.8	2 8;	21 16;	10 23;	30 7		
SW Draconis	12.8	+70 04	8.8— 9.6	0 13.7	7 19;	23 18;	9 17;	25 16		
T Crucis	15.9	−61 44	6.8— 7.6	6 17.6	2 20;	16 7;	6 12;	19 23		
R Crucis	18.1	−61 04	6.8— 7.9	5 19.8	1 15;	19 2;	6 13;	24 1		
S Crucis	12 48.4	−57 53	6.5— 7.6	4 16.6	5 3;	19 5;	7 23;	22 1		
W Virginis	13 20.9	− 2 52	8.7—10.4	17 06.5	5 8;	22 15;	9 21;	27 4		
SS Hydrae	25.0	−23 08	7.4— 8.1	8 4.8	6 15;	23 0;	9 10;	25 20		
RV Urs. Maj.	13 29.4	+54 31	9.2— 9.9	0 11.2	5 8;	19 9;	10 11;	24 22		
ST Virginis	14 22.5	− 0 27	10.3—11.4	0 09.9	5 19;	22 5;	8 15;	25 1		
V Centauri	25.4	−56 27	6.4— 7.8	5 11.9	4 2;	20 14;	7 1;	23 13		
RS Bootis	29.3	+32 11	8.9—10.0	0 09.1	2 17;	17 19;	10 10;	25 12		
RU Bootis	14 41.5	+23 44	12.8—14.3	0 11.9	7 22;	22 18;	7 13;	22 9		
R Triang. Austr.	15 10.8	−66 08	6.7— 7.4	3 09.3	5 0;	18 13;	8 21;	22 10		
S Triang. Austr.	15 52.2	−63 29	6.4— 7.4	6 07.8	4 11;	23 10;	6 2;	25 1		
S Normae	16 10.6	−57 39	6.6— 7.6	9 18.1	5 7;	24 19;	4 13;	24 1		
RW Draconis	33.7	+58 03	9.6—10.8	0 10.6	6 17;	24 11;	12 4;	29 21		
RV Scorpii	16 51.8	−33 27	6.7— 7.4	6 01.5	1 16;	19 21;	8 1;	20 14		
X Sagittarii	17 41.3	−27 48	4.4— 5.0	7 00.3	5 1;	19 2;	10 3;	24 3		
Y Ophiuchi	47.3	− 6 07	6.1— 6.5	17 02.9		17 14;	4 17;	21 20		
W Sagittarii	17 58.6	−29 35	4.3— 5.1	7 14.3	6 2;	21 7;	6 11;	21 16		
Y Sagittarii	18 15.5	−18 54	5.4— 6.2	5 18.6	4 21;	22 4;	3 18;	21 1		
U Sagittarii	26.0	−19 12	6.5— 7.3	6 17.9	3 21;	24 2;	7 14;	21 2		
Y Scuti	32.6	− 8 27	8.7— 9.2	10 08.3	2 18;	23 10;	14 2;	24 11		
Y Lyrae	34 2	+43 52	11.3—12.3	0 12.1	6 19;	18 21;	6 23;	25 1		
RZ Lyrae	39.9	+32 42	9.9—11.2	0 12.3	3 1;	21 11;	3 17;	22 3		
RT Scuti	18 44.1	−10 30	9.1— 9.7	0 11.9	5 16;	17 14;	5 10;	23 6		
κ Pavonis	18 46.6	−67 22	3.8— 5.2	9 02.2	9 17;	27 21;	6 23;	25 4		
U Aquilae	19 24.0	− 7 15	6.2— 6.9	7 00.6	7 7;	21 8;	5 9;	19 10		
XZ Cygni	30.4	+56 10	8.6— 9.3	0 11.2	2 21;	23 21;	7 21;	21 21		
U Vulpec.	32.2	+20 07	6.5— 7.6	7 23.5	2 5;	18 4;	4 4;	20 3		
SU Cygni	40.8	+29 01	6.2— 7.0	3 20.3	7 9;	22 19;	8 4;	23 13		
η Aquilae	47.4	+ 0 45	3.7— 4.5	7 04.2	2 13;	16 21;	8 10;	22 18		
S Sagittae	51.5	+16 22	5.6— 6.4	8 09.2	7 11;	24 5;	10 23;	27 18		
X Vulpec.	19 53.3	+26 17	9.5—10.5	6 07.7	1 8;	20 7;	9 6;	21 21		
X Cygni	20 39.5	+35 14	6.0— 7.0	16 09.3		15 14;	1 23;	18 8		
T Vulpec.	47.2	+27 52	5.5— 6.1	4 10.5	4 11;	17 18;	5 12;	23 7		
WY Cygni	52.3	+30 03	9.6—10.4	0 13.5	3 0;	16 11;	6 15;	20 2		
RV Capric.	55.9	−15 37	9.2—10.1	0 10.7	6 7;	19 17;	9 21;	23 7		
TX Cygni	20 56.4	+42 12	8.5— 9.7	14 17.4	9 18;	24 12;	9 5;	23 22		
VY Cygni	21 00.4	+39 34	8.8— 9.5	7 20.6	8 9;	16 6;	9 19;	25 13		
SW Aquarii	10.2	− 0 20	9.9—10.8	0 11.0	6 0;	19 19;	3 14;	17 8		
VZ Cygni	21 47.7	+42 40	8.2— 9.2	4 20.7	5 11;	20 1;	4 16;	19 6		
Y Lacertae	22 05.2	+50 33	9.1— 9.6	4 07.8	7 8;	24 15;	11 22;	29 6		
δ Cephei	25.5	+57 54	3.7— 4.6	5 08.8	1 12;	18 0;	4 2;	20 5		
Z Lacertae	36.9	+56 18	8.2— 9.0	10 21.1	5 7;	16 4;	7 22;	29 16		
RR Lacertae	37.5	+55 55	8.5— 9.2	6 10.1	6 10;	19 6;	8 12;	21 9		
V Lacertae	44.5	+55 48	8.5— 9.5	4 23.6	1 6;	16 5;	6 4;	21 2		
X Lacertae	22 45.0	+55 54	8.2— 8.6	5 10.7	4 0;	20 8;	6 16;	23 0		
SW Cassiop.	23 03.7	+58 11	9.2— 9.7	5 10.6	2 17;	19 1;	5 9;	21 16		
RS Cassiop.	32.6	+61 52	9.0—11.0	6 07.1	4 8;	23 6;	5 20;	24 17		
RY Cassiop.	47.2	+58 11	9.3—11.8	12 03.4	9 19;	21 23;	4 2;	16 6		
V Cephei	23 51.7	+82 38	6.0—7.0	0 23.9	6 10;	20 9;	4 5;	18 7		

Minima of Variable Stars of Short Period.

[Calculated by D. C. Kazarinoff at Goodsell Observatory.]

Given to the nearest hour in Greenwich mean time; to obtain Eastern Standard time subtract 5^h; Central Standard 6^h; etc. For "Summer Time" subtract 1^h less.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of minima in 1919							
					Sept.				Oct.			
	h m	° ′		d h	d	h	d	h	d	h	d	h
SY Androm.	0 08.0	+43 09	9.5—13.0	34 21.8			27	19				
RT Sculptor.	31.5	−26 13	9.6—10.5	0 12.3	6	1;	21	9;	6	17;	22	2
UU Androm.	38.5	+30 24	10.7—11.9	1 11.7	3	14;	18	11;	3	8;	18	4
U Cephei	0 53.4	+81 20	7.0— 9.0	2 11.8	7	10;	22	9;	7	8;	22	7
Z Persei	2 33.7	+41 46	9.4—12	3 01.4	6	5;	24	13;	6	18;	25	2
TW Cassiop.	37.6	+65 19	8.2— 9.0	1 10.3	9	18;	24	0;	8	7;	22	14
RY Persei	39.0	+47 43	8.0—10.3	6 20.7	2	11;	23	1;	6	19;	20	12
RZ Cassiop.	39.9	+69 13	6.9— 8.1	1 04.7	3	18;	18	2;	9	15;	23	23
TX Cassiop.	44.4	+62 22	9.4—10.1	2 22.2	2	12;	20	2;	7	15;	25	4
ST Persei	53.7	+38 47	8.5—10.5	2 15.6	3	22;	19	19;	5	17;	21	14
RX Cassiop.	2 58.8	+67 11	8.6— 9.1	32 07.6			27	4			29	12
Algol	3 01.7	+40 34	2.3— 3.5	2 20.8	5	2;	22	7;	9	11;	26	16
RT Persei	16.7	+46 12	9.5—11.5	0 20.4	9	14;	23	4;	6	18;	20	8
λ Tauri	55.1	+12 12	3.3— 4.2	3 22.9	8	11;	24	6;	10	2;	25	21
RW Tauri	3 57.8	+27 51	7.1—<11	2 18.5	8	3;	24	7;	11	8;	27	23
RV Persei	4 04.2	+33 59	9.5—11.0	1 23.4	3	13;	19	8;	5	3;	20	22
RW Persei	13.3	+42 04	8.8—11.0	13 04.8	7	3;	20	8;	3	12;	29	22
SZ Tauri	31.4	+18 20	7.2— 7.7	3 03.6	1	2;	20	0;	8	21;	27	19
RS Cephei	4 48.6	+80 06	9.5—12.0	12 10.1	5	20;	18	6;	13	2;	25	12
TT Aurigae	5 02.8	+39 27	7.8— 8.7	0 16.0	9	3;	22	11;	5	19;	25	19
RY Aurigae	11.5	+38 13	10.7—11.7	2 17.5	3	16;	20	1;	6	10;	22	18
RZ Aurigae	42.9	+31 40	10.6—13.3	3 00.3	5	2;	23	4;	11	5;	29	7
SV Tauri	45.8	+28 05	9.4—11.0	2 04.0	9	1;	26	9;	13	17;	31	1
Z Orionis	50.2	+13 40	9.7—10.7	5 04.9	7	8;	17	8;	8	13;	29	9
SV Gemin.	54.6	+24 28	9.8—<11	4 00.2	2	16;	26	17;	12	17;	28	18
RW Gemin.	5 55.4	+23 08	9.5—11.0	2 20.8	6	8;	23	13;	10	18;	22	5
U Columbae	6 11.2	−33 03	9.2—10.0	2 19.2	6	15;	23	10;	10	5;	27	0
SX Gemin.	22.0	+20 37	10.8—11.5	1 08.8	8	17;	25	3;	11	13;	27	22
RW Monoc.	29.3	+ 8 54	9.0—10.8	1 21.7	7	11;	22	17;	7	23;	23	5
RX Gemin.	43.6	+33 21	8.8— 9.6	12 05.0	4	7;	16	12;	10	22;	23	3
RU Monoc.	6 49.4	− 7 28	9.8—10.5	0 21.5	1	18;	23	6;	7	14;	21	22
R Can. Maj.	7 14.9	−16 12	5.8— 6.4	1 03.3	3	14;	24	1;	7	16;	21	7
RY Gemin.	21.7	+15 52	8.9—<10	9 07.2	7	20;	17	4;	5	18;	24	8
Y Camelop.	27.6	+76 17	9.5—12	3 07.3	1	11;	21	7;	11	3;	24	8
TX Gemin.	30.3	+17 8	10.0—11.9	2 19.2	6	20;	23	15;	10	10;	27	5
RR Puppis	43.5	−41 08	9.4—10.7	6 10.3	2	8;	21	15;	10	22;	23	18
V Puppis	7 55.4	−48 58	4.1— 4.8	1 10.9	4	8;	18	21;	3	10;	17	23
X Carinae	8 29.1	−58 53	7.9— 8.7	0 13.0	5	3;	21	8;	7	14;	23	20
S Cancri	8 38.2	+19 24	8.2—10	9 11.6	6	4;	25	3;	4	15;	23	14
RX Hydrae	9 00.8	− 7 52	9.1—10.5	2 6.8	6	10;	20	3;	3	20;	24	8
S Velorum	29.4	−44 46	7.8— 9.3	5 22.4	4	17;	16	14;	4	9;	22	4
Y Leonis	9 31.1	+26 41	9.3—11.2	1 16.5	6	23;	20	11;	3	23;	24	4
RR Velorum	10 17.8	−41 36	10.0—10.9	1 20.5	3	5;	18	1;	2	21;	17	17
SS Carinae	10 54.2	−61 23	12.2—12.8	3 07.2	5	18;	18	23;	8	18;	21	23
ST Urs. Maj.	11 22.4	+45 44	6.7— 7.2	8 19.2	4	14;	22	4;	9	19;	27	10
RW Urs. Maj.	35.4	−52 34	10.3—11.4	7 07.9	2	12;	17	3;	9	3;	23	19
Z Draconis	11 39.8	+72 49	9.9—13.6	1 08.6	7	18;	21	8;	11	17;	25	7
RZ Centauri	12 55.6	−64 05	8.5— 8.9	1 21.0	2	21;	17	22;	2	22;	17	22
RS Can. Ven.	13 06.3	+36 28	7.5—12.5	4 19.1	4	18;	23	23;	13	3;	22	18
SS Centauri	13 07.2	−63 37	8.8—10.4	2 11.5	6	0;	20	21;	5	18;	20	15
133926 Hydrae	13 39.0	−26 23	8.6—12.7	2 21.5	7	12;	19	2;	6	11;	23	20
δ Librae	14 55.6	− 8 07	4.8— 6.2	2 07.9	7	23;	21	23;	12	21;	26	20

Minima of Variable Stars of Short Period—Continued.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of minima in 1919							
					Sept.				Oct.			
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h	d h
U Coronae	15 14.1	+32 01	7.6— 8.7	3 10.9	7 9;	21 5;	11 22;	25 17				
TW Draconis	32.4	+64 14	7.3— 8.9	2 19.3	5 0;	21 20;	8 16;	25 12				
SS Librae	15 43.4	−15 14	9.3—11.5	0 18.4	8 13;	23 21;	9 4;	24 12				
SW Ophiuchi	16 11.1	− 6 44	9.2—10.0	2 10.7	4 18;	19 10;	11 11;	26 3				
SX Ophiuchi	12.6	− 6 25	10.5—11.2	2 01.5	6 2;	22 17;	9 5;	25 17				
R Arae	31.1	−56 48	6.8— 7.9	4 10.2	9 16;	18 12;	6 5;	23 22				
TT Herculis	16 49.9	+17 00	8.9— 9.3	20 18.1	9 10;	19 3;	9 21;	20 23				
TU Herculis	17 09.8	+30 50	9.5—12	2 06.4	7 11;	21 1;	4 16;	25 2				
U Ophiuchi	11.5	+ 1 19	6.0— 6.7	0 20.1	2 23;	19 18;	6 13;	23 7				
u Herculis	13.6	+33 12	4.6— 5.4	2 01.2	5 12;	17 19;	6 6;	18 13				
TX Herculis	15.4	+42 00	8.3— 9.0	1 00.7	2 9;	16 19;	8 10;	22 20				
RV Ophiuchi	29.8	+ 7 19	9. —12	3 16.5	3 11;	18 5;	10 8;	25 2				
SZ Herculis	36.0	+33 01	9.5—10.3	0 19.6	7 8;	23 17;	10 2;	26 11				
TX Scorpii	48.6	−34 13	7.5— 8.2	0 22.6	1 18;	16 20;	9 11;	24 13				
UX Herculis	49.7	+16 57	8.8—10.5	1 13.2	7 0;	22 11;	7 23;	23 11				
Z Herculis	53.6	+15 09	7.1— 7.9	3 23.8	7 19;	23 19;	9 18;	25 17				
WX Sagittae	53.6	−17 24	9.2—10.8	2 03.1	2 22;	19 23;	7 0;	24 1				
WY Sagittae	17 54.9	−23 1	9.5—10.6	4 16.0	5 18;	24 10;	3 18;	22 10				
SX Draconis	18 03.0	+ 58 23	9.3—10.5	5 04.1	6 18;	17 2;	7 19;	28 11				
RS Sagittarii	11.0	−34 08	5.9— 6.3	2 10.0	7 19;	22 17;	6 19;	21 7				
V Serpentis	11.1	−15 34	9.5—11.1	3 10.9	5 7;	19 2;	9 19;	23 15				
RZ Scuti	21.1	− 9 15	7.4— 8.3	15 03.2	9 20;	24 23;	10 3;	25 6				
RZ Draconis	21.8	+58 50	9.5—10.2	0 13.2	7 18;	22 2;	6 9;	20 17				
RX Herculis	26.0	+12 32	7.0— 7.6	0 21.3	1 18;	23 2;	7 7;	21 13				
SX Sagittarii	39.7	−30 36	8.7— 9.8	2 01.8	8 6;	24 20;	11 11;	28 2				
RR Draconis	40.8	+62 34	9.3—13	2 19.9	5 13;	22 13;	9 12;	26 12				
RS Scuti	43.7	−10 21	9.3—10.3	0 15.9	5 9;	18 15;	8 14;	21 21				
β Lyrae	46.4	+33 15	3.4— 4.1	12 21.8	10 6;	23 4;	6 2;	19 0				
U Scuti	18 48.9	−12 44	9.1— 9.6	0 22.9	8 10;	23 16;	8 23;	24 6				
RX Draconis	19 01.1	+58 35	9.3—10.2	1 21.4	6 20;	22 0;	7 3;	22 7				
RV Lyrae	12.5	+32 15	11. —12.8	3 14.4	6 9;	20 19;	12 9;	26 19				
RS Vulpec.	13.4	+22 16	6.9— 8.0	4 11.4	7 3;	25 1;	12 23;	30 20				
U Sagittae	14.4	+19 26	6.5— 9.0	3 09.1	6 2;	19 14;	9 21;	23 10				
Z Vulpec.	17.5	+25 23	7.3— 8.5	2 10.9	3 21;	18 15;	10 17;	25 11				
TT Lyrae	24.3	+41 30	9.4—11.6	5 05.8	6 3;	21 20;	7 14;	23 7				
UZ Draconis	26.1	+68 44	9.0— 9.8	1 15.1	2 13;	22 3;	5 4;	24 18				
SY Cygni	19 42.7	+32 28	10 —12	6 00.2	4 19;	16 19;	4 20;	22 20				
WW Cygni	20 00.6	+41 18	9.3—13.4	3 07.6	4 17;	17 23;	7 21;	21 4				
SW Cygni	03.8	+46 01	9. —11.7	4 13.8	6 22;	25 5;	13 12;	31 19				
VW Cygni	11.4	+34 12	9.8—11.8	8 10.3	5 17;	22 13;	9 10;	26 7				
RW Capric.	12.2	−17 59	8.8—10.6	3 09.4	6 1;	19 15;	9 23;	23 13				
UW Cygni	19.6	+42 55	10.5—13	3 10.8	7 6;	21 1;	4 20;	18 16				
V Vulpec.	32.3	+26 15	8.2—9.8	37 19.0		29 1						
W Delphini	33.1	+17 56	9.4—12.1	4 19.4	4 11;	23 16;	12 22;	22 13				
RR Delphini	38.9	+13 35	10.5—11.8	4 14.4	5 19;	24 4;	12 14;	30 23				
Y Cygni	48.1	+34 17	7.1— 7.9	1 12.0	3 0;	18 0;	2 23;	17 23				
WZ Cygni	49.3	+38 27	9.9—10.8	0 14.0	1 19;	16 23;	9 18;	24 23				
RR Vulpec.	20 50.5	+27 32	9.6—11.0	5 01.2	4 11;	24 16;	4 2;	24 7				
VV Cygni	21 02.3	+45 23	12.1—13.8	1 11.4	1 22;	16 17;	8 20;	23 15				
AE Cygni	09.0	+30 20	10.8—11.4	0 23.3	5 17;	25 2;	4 18;	24 4				
RY Aquarii	14.8	−11 14	8.8—10.4	1 23.2	1 5;	16 23;	2 17;	18 10				
RT Lacertae	21 57.4	+43 24	9.1—10.5	5 01.7	2 6;	22 13;	2 17;	23 0				
UZ Cygni	55.2	+43 52	8.9—11.6	31 07.3		21 16		22 23				
RW Lacertae	22 40.6	+49 08	10.2—11.2	5 04.4	1 20;	17 10;	2 23;	23 17				
TT Androm.	23 08.7	+45 36	11.3—12.6	2 18.4	7 7;	23 21;	10 11;	27 1				
Y Piscium	29.3	+ 7 22	9.0—12.0	3 18.3	5 21;	20 22;	6 0;	21 1				
TW Androm.	23 58.2	+32 17	8.6—11.5	4 02.9	5 4;	21 16;	8 3;	24 15				

NOTES FOR OBSERVERS.

Monthly Report of the American Association of Variable Star Observers, May and June, 1919.

It is a pleasure to welcome our Secretary back from his western trip of several months. Mr. Olcott has communicated a short list of observations made while at Clark Observatory. He gave several lectures on variable stars, and had an excellent opportunity to see the Mount Wilson Observatory, including the 100-inch reflector.

It is evident that the Daylight Saving plan has shortened the list of observations in the summer months. One of the members voices the sentiments of many of our observers when he says ". . . my scant list is due partly to the daylight saving nonsense which makes observing too late a pastime for a tired business man these nights."

By the kindness of Professor H. C. Wilson, copies of POPULAR ASTRONOMY giving an account of the May Meeting were sent to the recently elected members. Mr. Suter has already contributed a list, designated by "Su".

Mr. D. B. Pickering has completed the remounting of a 5¼-inch telescope recently loaned to him by the Harvard Observatory, and has already obtained results which indicate the benefits of the arrangement. He and Messrs. Bouton and Hay caught SS Cygni on the rise, after an interval of 58 days from the previous rise. Lieut. Francis H. Hay's contributions are indicated by "Hy". It is especially an advantage to welcome him back to the ranks of active observers, on account of his far western location. He is now using the 6-inch telescope of the Clark Observatory, Los Angeles, having recently returned from war service.

Dr. Mundt spent the month of June at the Lick Observatory, observing with the 12-inch telescope.

The McAteer 4-inch telescope has been loaned to Mr. C. E. Barns, who has not yet received his own lens which was loaned to the Government at the beginning of the war.

One of our members in Switzerland, M. Janczewski, calls attention to an error on the blue print chart of S Serpentis, 151714, traced by "D. B. P." The star there marked 13.1, near the variable, should read 12.1.

The following observers contributed to this report:—Messrs. Bouton, Dawson, Hay, Hunter, Janczewski, Luyten, McAteer, Mundt, Murray, Olcott, Peltier, de Perrot, D. B. Pickering, Rhorer, Suter, Tapia, Vrooman, Woglom, Yalden, and Miss Young.

IDA E. WOODS,
Acting Secretary.

VARIABLE STAR OBSERVATIONS, May and June, 1919.

Apr. 0 = 2422049 June 0 = 2422110
May 0 = 2422079 July 0 = 2422140

001046
X Androm.
J.D. Est Obs.
242
2131.8<12.0 M

001755
T Cassiop.
2097.5 11.3 Lt
2127.8 10.4 M

001726
T Androm.
2131.8 10.3 M

001838
R Androm.
2131.8<11.6 M

001909
S Ceti
2131.8 9.2 M

004047
U Cassiop.
2131.8 11.4 M

004132
RW Androm.
2131.8<11.5 M

004958
W Cassiop.
2099.5 11.3 Lt
2131.8 8.7 M

014958
X Cassiop.
2102.5 12.6 Lt

015354
U Persei
2192.6 8.0 Lt

021024
R Arietis
2138.8 11.3 M

021143a
W Androm.
2102.6 10.0 Lt

024356
W Persei
2138.9 9.2 Pt

033362
U Camelop.
2084.4 8.0 Lt

043065
T Camelop.
2084.4 8.5 Lt

043274
X Camelop.
J.D. Est.Obs.
242
2084.4 8.4 Lt
97.7 8.2 O

043263
R Reticuli
2101.6<12.5 δ

043562
R Doradus
2101.6 6.7 δ

050953
R Aurigae
2068.4 9.5 Lt

053068
S Camelop.
2084.4 8.3 Lt

053920
Y Tauri
2068.4 7.9 Lt

054319
SU Tauri
2079.6 9.5 B

054974
V Camelop.
2107.6<12.2 Y

054920
U Orionis
2068.4 10.4 Lt

055686
R Octantis
2101.6 8.3 δ
07.6 7.5

060547
SS Aurigae
2079.6<13.5 B
81.6<12.4 M
84.6 11.0 Y
85.6 10.8 Y
2102.7<13.0 B

063159
U Lyncis
2107.6<12.0 Y

063558
S Lyncis
2079.6 9.0 B
2102.7 10.2 B

064030
X Gemin.
2068.4 11.0 Lt

065355
R Lyncis
J.D. Est. Obs.
242
2068.4 8.7 Lt
2107.6 9.1 Y

070122a
R Gemin.
2077.4 12.2 Lt

070310
R Can. Min.
2079.6 7.8 B

071044
L_2 Puppis
2001.6 4.2 δ_2

071713
V Gemin.
2077.4 11.4 Lt

072708
S Can. Min.
2068.4 11.0 Ja
80.6 11.5 M

073723
S Gemin.
2080.6<12.4 M

074323
T Gemin.
2080.6<11.5 M

074922
U Gemin.
2066.4<12.1 Lt
68.4<12.3
79.7<13.7 B
80.6<12.4 M
81.6<12.4
85.6<13.0 Y
97.7<12.4 O

081112
R Cancri
2068.4 7.5 Lt
79.7 7.8 B
97.4 8.3 Lt
97.6 8.5 Ya
2100.7 8.6 Pt

082405
RT Hydrae
2079.7 8.4 B

083350
X Urs. Maj.
2104.7<12.6 B

085008
T Hydrae
J.D. Est. Obs.
242
2077.4 10.0 Lt

085120
T Cancri
2079.7 8.3 B

090151
V Urs. Maj.
2101.5 10.0 Pe_2
04.7 10.2 B
07. 10.4 Pe
12.7 9.9 Mu
24.6 10.2 B

091868
RW Carinae
2071.6 9.6 Tp
79.6 9.6
2101.6 10.6 δ
01.6 10.1 Tp
07.5 10.9
07.6 10.9 δ

092962
R Carinae
2071.6 8.9 Tp
2101.6 9.8 δ
01.6 10.0 Tp
07.5 9.5
07.6 9.9 δ

093178
Y Draconis
2107.6<12.0 Y

093934
R Leo. Min.
2080.6 10.0 M
81.6 9.6 Wg
84.4 9.8 Lt
2102.7 9.8 B
29.6 11.3

094023
RR Hydrae
2101.6 13.5 δ

094211
R Leonis
2066.3 7.1 Lt
71.3 7.6 Ja_2
77.4 7.2 Lt
80.6 6.9 M
81.1 7.4 My_2
81.7 7.1 Mu
81.8 7.8 Ro_2
83.4 7.6 Ja
94.5 8.0

R Leonis
J.D. Est.Obs.
242
2097.6 7.6 My
97.6 7.7 Ya
97.7 7.5 O
99.4 8.2 Lt
2100.6 7.8 Ro_2
00.7 7.7 Pt
02.7 7.3 B
05.6 7.8 Ya
07. 7.8 Pe
29.0 8.1 Hy_3

094262
l Carinae
2071.6 4.4 Tp
79.6 3.6
2101.6 4.1 δ
01.6 4.2 Tp
07.5 4.2
07.6 4.1 δ

100661
S Carinae
2078.6 5.6 Tp_2
2101.6 6.6 δ_2
01.6 6.5 Tp
07.6 6.8 δ_2

103212
U Hydrae
2084. 5.7 Pe
95. 5.8

103769
R Urs. Maj.
2068.5 8.0 Lt
81.3 8.4 My_3
81.7 8.1 Mu
92.4 8.4 Lt
97.7 8.4 M
2106.7 9.6 Pt
12.7 9.7 Mu
20.7 9.6 B
25.6 8.9 M
29.0 9.7 Hy_3

104620
V Hydrae
2106.7 8.1 Pt

104814
W Leonis
2113.6<12.2 B

114441
X Centauri
2078.6 12.2 Tp_2
2101.6 11.2 δ
01.6 11.2 Tp

VARIABLE STAR OBSERVATIONS, May and June, 1919—Continued.

115919
R Com. Ber.

J.D. 242	Est.	Obs.
2072.5	12.0	Ja
84.5	11.2	
97.5	9.6	
97.7	9.2	M
2102.7	8.8	B
08.2	8.2	B_2
08.5	8.4	Ja
13.6	8.0	B
22.6	7.8	B_3
25.7	8.0	M
29.6	7.9	B
29.6	8.0	Pi

120012
SU Virginis

2068.4	11.3	Ja
84.5	11.3	
2101.5	11.5	
13.6	12.3	B
29.6	<12.4	Pi

120905
T Virginis

2083.5	12.6	Ja

121418
R Corvi

2077.4	12.4	Lt

122001
SS Virginis

2097.7	9.3	M
2104.7	8.3	B
22.7	8.0	
25.7	8.5	M
29.6	8.6	Pi
39.6	8.0	Hu

122532
T Can. Ven.

2107.8	9.9	M
25.6	9.8	Pi
25.7	9.8	M

123160
T Urs. Maj.

2066.4	8.8	Lt
81.7	9.4	Mu
92.4	10.1	Lt
97.7	11.2	M
2107.6	10.0	Y
20.7	11.3	B
25.6	12.4	M
39.6	11.8	Hu

123307
R Virginis

2053.4	6.9	Ja
66.4	7.6	Lt
71.4	8.0	Ja_2
81.7	8.9	Wg
84.5	9.3	Ja

R Virginis

2095.4	10.4	Ja
95.4	10.0	Lt
97.7	10.6	M
2104.7	10.4	B
22.6	11.0	
25.7	11.3	M
29.6	12.0	Pi
30.6	10.8	Ya_2
39.6	10.2	Hu

123459
RS Urs. Maj.

2097.7	12.0	M
2120.7	9.3	B
25.6	8.8	M

123961
S Urs. Maj.

2066.4	10.6	Lt
81.7	10.3	Mu
92.4	10.2	Lt
97.7	11.5	M
2107.6	11.6	Y
20.7	11.6	B
25.6	12.0	M
39.6	10.1	Hu

124045
Y Can. Ven.

2100.4	5.9	Lt

124204
RU Virginis

2113.6	12.1	B
39.6	11.6	Hu

124606
U Virginis

2068.4	10.6	Ja
84.5	12.1	
2101.5	12.4	

131283
U Octantis

2071.6	13.6	Tp
79.6	13.6	
2101.6	13.0	
02.7	13.5	δ
07.6	13.5	

131546
V Can. Ven.

2066.4	6.8	Lt
99.5	7.2	

132422
R Hydrae

2081.7	8.8	Mu
2102.7	7.5	δ_2

132706
S Virginis

2053.4	8.1	Ja
68.5	8.6	
81.7	9.2	Mu
84.4	9.0	Lt
84.5	9.2	Ja
95.4	9.7	
97.7	9.6	M
2106.7	9.9	Pt
12.7	10.3	Mu
31.6	11.5	Ya

133273
T Urs. Min.

2102.6	12.6	Lt

133633
T Centauri

2071.7	5.8	Tp
79.6	6.3	
2101.6	6.9	
02.7	7.0	δ_2
07.6	7.5	

134236
RT Centauri

2071.7	11.9	Tp
2101.6	11.6	
02.7	12.1	δ

134440
R Can. Ven.

2066.4	11.1	Lt
99.5	10.3	
2107.8	10.1	M
25.6	9.3	Pi
25.7	9.1	M

134677
T Apodis

2079.6	10.1	Tp
2101.6	11.6	
02.7	11.3	δ

135908
RR Virginis

2070.5	12.0	Ja
84.5	13.0	
97.5	<13.1	

140113
Z Bootis

2097.4	13.4	Lt

140512
Z Virginis

2071.4	11.9	Ja
84.4	12.5	
98.5	13.0	

140528
RU Hydrae

2077.6	<13.5	Tp
2102.7	<14.0	δ

140959
R Centauri

2078.6	6.3	Tp_2
2102.3	6.7	δ_3
07.6	6.8	δ

141567
U Urs. Min.

2102.6	9.2	Lt
2125.7	8.6	M

141954
S Bootis

2130.1	8.9	Pi_2

142205
RS Virginis

2070.4	7.7	Ja
84.4	7.8	Lt
84.5	7.5	Ja
95.4	7.8	
2104.7	7.5	B

142584
R Camelop.

2068.4	9.6	Lt
97.4	8.4	
2125.7	8.6	M

142539
V Bootis

2077.4	8.3	Lt
80.6	7.9	M
81.3	7.7	My_3
81.6	8.0	Ro_2
94.6	7.7	Ro
97.6	7.8	My
97.7	7.7	O
2100.6	7.8	Ro_2
05.4	7.7	Lt
05.6	7.5	Wg
09.8	7.8	Pt
12.7	7.9	Mu
14.6	7.8	Ro
22.6	7.8	Pi
25.7	7.7	M
31.7	7.9	Pt
34.6	8.0	Pi
39.6	7.9	Hu

143227
R Bootis

2066.4	12.3	Lt
77.4	11.9	
2105.4	10.3	
06.7	10.1	Pt
07.8	9.9	M
12.7	9.6	Mu
25.7	8.6	M
27.6	8.4	Pi_2
31.7	8.5	Pt

144918
U Bootis

2122.7	11.1	B
25.7	10.9	M
36.6	10.9	V

145254
Y Lupi

2079.6	13.6	Tp
2102.7	<14.2	δ

151731
S Cor. Bor.

2066.4	9.7	Lt
2102.6	9.9	Y
06.7	10.0	B
06.8	10.0	M
12.7	10.0	Mu
29.7	11.1	Ya
30.6	10.9	Pi_2
31.8	11.0	M
39.6	11.0	Hu

151714
S Serpentis

2084.5	12.1	Ja
97.4	11.9	Lt
98.5	11.8	Ja
2106.8	11.5	M
09.5	11.5	Ja
32.8	9.7	M

151822
RS Librae

2128.6	9.6	B

152714
RU Librae

2128.6	<12.5	B

152849
R Normae

2078.6	10.6	Tp_2
2102.7	11.9	δ

153378
S Urs. Min.

2081.7	10.9	Mu
84.4	11.3	Lt
2112.7	11.1	Mu
26.7	11.7	
33.8	11.3	M

153654
T Normae

2078.6	10.2	Tp_2
2102.7	11.3	δ

154428
R Cor. Bor.

2066.4	6.3	Lt
68.4	6.4	
69.4	5.9	Ja
77.4	6.3	Lt

VARIABLE STAR OBSERVATIONS, May and June, 1919—Continued.

R Cor. Bor.

J.D. 242	Est.	Obs.
2080.6	6.3	Ro
81.6	6.0	M
81.6	6.5	My
81.7	6.1	Mu
82.6	6.0	Ro
83.6	6.2	My
84.	6.0	Pe
84.4	6.3	Lt
84.9	6.2	Pt
86.7	6.1	Mu
92.6	6.2	My
94.7	6.2	Mu
96.6	6.0	Ro
96.7	6.1	Mu
97.5	5.6	Ja
97.6	6.0	My
97.6	6.0	Wg
97.7	6.1	O
2100.	5.9	Pe
00.7	6.3	Pt
02.	6.0	Pe
02.7	6.2	Mu
03.7	6.3	Pt
03.8	6.3	Mu
04.6	5.9	Ro
04.8	6.2	Pt
05.5	6.3	Lt
05.7	6.3	Mu
05.9	6.3	Pt
06.6	6.0	My
06.6	6.0	Wg
06.7	6.3	Pt
07.	6.0	Pe
07.7	6.3	Pt
08.	6.0	Pe
08.7	6.2	Pt
09.	6.0	Pe
09.7	6.3	B
09.7	6.2	Mu
09.8	6.2	Pt
10.7	6.2	
11.7	6.2	Mu
13.8	6.0	M
14.6	6.0	Ro
15.7	6.2	Mu
15.8	6.3	Pt
16.8	6.3	
25.7	6.0	M
25.7	6.2	Mu
25.7	6.2	Pt
26.7	6.3	
27.7	6.0	Hy
27.7	6.2	Pt
27.8	6.1	Mu
28.7	5.8	Hy
28.7	6.3	Pt
29.7	6.3	
30.7	6.0	Hy
31.7	6.3	Pt
31.7	5.9	Ya

R Cor. Bor.

J.D. 242	Est.	Obs.
2132.8	6.3	Mu
33.8	6.0	M
36.7	6.3	Pt
36.7	5.4	V
36.8	6.2	M
37.7	6.4	Pt
37.7	5.6	Su
38.7	6.4	Pt
39.6	5.6	Hu
39.8	6.4	Pt
40.7	6.4	
40.8	6.1	Mu

154536
X Cor. Bor.

2068.5	11.9	Lt
81.7	13.0	M

154639
V Cor. Bor.

2081.7	10.3	M
84.4	11.2	Lt
2113.8	10.4	M
28.6	10.4	Pi

154615
R Serpentis

2066.4	7.4	Lt
70.4	7.7	Ja_3
83.5	8.1	Ja
94.5	8.1	Lt
97.0	8.4	Ja_2
2100.7	8.6	Pt
05.4	8.7	Lt
06.7	8.7	B
06.8	8.4	M
07.5	8.7	Ja
12.7	8.7	Mu
16.8	9.0	Pt
28.6	9.4	Pi
36.7	9.6	V

154736
R Lupi

2102.7	<13.5	δ

155229
Z Cor. Bor.

2133.8	<12.5	M

155947
X Herculis

2099.7	7.0	Mu_2
2108.	6.2	Pe
10.7	6.8	Mu_2
15.7	6.8	Mu
29.2	6.7	Mu_2

160210
U Serpentis

2068.5	11.4	Lt
87.4	9.7	

U Serpentis

J.D. 242	Est.	Obs.
2105.4	9.4	Lt
06.6	9.3	Y
06.7	9.1	Pt
06.8	9.5	M
27.6	9.3	B
28.6	9.2	Pi
31.7	9.1	Pt
32.8	9.2	M

160325
SX Herculis

2068.4	7.8	Lt
97.4	8.7	

160625
RU Herculis

2068.4	9.0	Lt
71.4	9.5	Ja
81.7	9.4	M
97.4	10.3	Lt
2109.5	10.7	Ja
28.6	10.8	Pi
31.8	10.7	M

161138
W Cor. Bor.

2068.5	9.2	Lt
2102.6	11.2	Y
06.7	11.3	B
06.8	11.8	M
31.8	12.2	

161122a
R Scorpii

2083.5	12.7	Ja
2100.0	11.6	Ja_2
07.5	11.1	Ja
31.8	11.7	M

161122b
S Scorpii

2071.5	11.0	Ja
83.5	10.0	
2100.0	10.8	Ja_2
07.5	10.9	Ja
31.8	<12.0	M

161122c
T Scorpii

2071.5	10.8	Ja
83.5	10.9	
2100.0	10.8	Ja_2
07.5	10.7	Ja
31.8	10.6	M

161607
W Ophiuchi

2131.6	11.6	B
31.8	11.7	M

162119
U Herculis

J.D. 242	Est.	Obs.
2097.4	13.0	Lt
2131.8	12.0	M

162112
V Ophiuchi

2097.5	8.2	Lt
2106.7	7.5	B
29.7	7.8	

162542
g Herculis

2099.7	5.4	Mu_2
2110.7	5.4	
15.7	5.4	Mu
29.2	5.3	Mu_2

162807
SS Herculis

2077.4	12.1	Lt
97.4	11.6	
2104.7	11.1	B
27.6	9.2	
40.8	9.7	M
44.6	9.9	Hu

162816
S Ophiuchi

2131.6	11.6	B

163172
R Urs. Min.

2110.7	9.4	M
25.7	9.7	

163137
W Herculis

2081.7	8.8	M
84.4	8.5	Lt
86.5	9.2	Ja
2103.7	9.5	Pt
04.7	9.5	B
05.4	9.5	Lt
06.6	10.0	Y
07.5	9.4	Ja
24.6	10.7	B
25.7	10.6	M
28.7	11.0	Pi
44.6	11.2	Hu

163266
R Draconis

2097.4	12.2	Lt
2106.6	12.0	Y
10.7	11.5	M
25.7	10.8	

164055
S Draconis

2081.7	8.7	M
2103.7	9.1	Pt
13.8	8.6	M
28.7	9.2	Pt

164319
RR Ophiuchi

J.D. 242	Est.	Obs.
2106.7	8.6	B

164715
S Herculis

2068.4	11.1	Lt
87.4	10.6	
2104.7	8.6	B
05.4	9.1	Lt
06.8	8.5	M
27.6	8.5	B
31.7	9.0	Pt
40.8	8.2	M

164844
RS Scorpii

2102.7	10.8	δ

165030
RR Scorpii

2079.6	9.5	Tp
2103.2	10.4	δ_2

165202
SS Ophiuchi

2131.8	12.3	M

165631
RV Herculis

2081.7	13.3	M
2115.7	14.1	Mu
30.2	13.1	Mu_2
31.8	12.5	M
44.6	10.9	Hu
49.8	11.7	M

170215
R Ophiuchi

2106.8	9.8	M
12.7	9.4	Mu
29.7	8.4	Hy_2
31.8	8.8	M
37.7	8.4	Pt

171401
Z Ophiuchi

2084.5	8.6	Lt
86.5	8.5	Ja
2106.7	9.0	B
06.7	9.1	Pt
29.6	9.2	B
36.7	9.6	V

171723
RS Herculis

2041.5	9.5	Lt
51.5	9.3	
68.4	9.4	
86.5	8.4	Ja
2104.7	8.4	B
06.7	8.2	Pt
07.	8.6	Pe

VARIABLE STAR OBSERVATIONS, May and June, 1919—Continued

RS Herculis

J.D. 242	Est.	Obs.
2107.5	8.4	Ja
16.8	9.0	Pt
27.6	8.9	B
29.7	9.0	Hy_2
31.8	9.4	M

172486
S Octantis

2079.5	8.7	Tp
2102.7	8.3	δ
07.6	8.4	

172809
RU Ophiuchi

2131.6	13.8	B

173557
TY Draconis

2101.	9.0	Pe

175458a
T Draconis

2106.6	10.8	Y

175458b
UY Draconis

2106.6	11.0?	Y

175519
RY Herculis

2139.8	<12.1	M

180363
R Pavonis

2079.6	12.1	Tp

180565
W Draconis

2109.7	<13.0	B

180531
T Herculis

2068.4	8.5	Lt
84.9	9.6	Pt
2102.	11.2	Pe
05.4	12.0	Lt
05.8	11.4	M
06.7	11.6	B
09.5	11.4	Ja
39.6	12.0	Hu

180931
TV Herculis

2102.	9.3	Pe
08.	9.2	Pe_2

181136
W Lyrae

2068.4	9.1	Lt
97.7	8.0	M
2102.6	8.5	Y
05.4	8.6	Lt

W Lyrae

J.D. 242	Est.	Obs.
2106.7	8.5	Pt
07.	10.2	Pe
13.8	8.4	M
20.7	9.0	B
29.0	9.7	Hy_3
30.2	9.8	Pi_2
34.7	10.0	Mu
37.7	9.9	
44.6	10.6	Hu

181103
RY Ophiuchi

2097.5	13.0	Lt
2120.7	<11.9	B

182133
RV Sagittarii

2079.7	12.0	Tp

182224
SV Herculis

2084.4	13.4	Lt

182306
T Serpentis

2084.4	10.4	Lt
2120.7	<12.1	B
40.8	<11.5	M

183149
SV Draconis

2102.6	<13.0	Y

183225
RZ Herculis

2084.4	11.8	Lt
2102.6	10.0	Y
05.4	9.7	Lt

183308
X Ophiuchi

2084.5	7.8	Lt
2106.8	6.0	M
20.7	6.4	B
40.8	6.5	M

184134
RY Lyrae

2143.6	11.9	Hu

184243
RW Lyrae

2128.6	<13.7	B

184205
R Scuti

2084.5	7.5	Ja
84.9	7.8	Pt
94.4	7.4	Lt
94.5	7.5	Ja
97.5	7.3	Lt
98.5	7.4	Ja

R Scuti

J.D. 242	Est.	Obs.
2099.4	7.3	Lt
2100.	7.0	Pe
01.	7.1	
01.5	7.3	Ja
02.6	7.2	Lt
03.6	7.3	δ
03.7	7.0	Pt
04.8	7.0	
05.5	7.2	Lt
05.8	7.7	M
05.9	6.9	Pt
06.7	7.1	
07.5	7.1	Ja
07.6	7.1	Lt
07.8	7.1	Pt
08.5	7.0	Ja
08.9	7.1	Pt
09.5	6.9	Ja
09.8	7.2	Pt
10.7	7.1	
11.	6.7	Pe
11.7	6.8	Mu
14.	6.6	Pe
15.7	6.8	Mu
15.8	7.3	Pt
16.8	7.3	
19.4	6.3	Lt
19.7	7.3	Pt
19.8	5.9	M
21.4	6.1	Lt
26.7	6.0	Pt
27.7	5.9	
27.7	5.5	Su
27.8	4.9	Mu
28.7	5.8	Hy
28.7	5.5	Pt
29.7	5.7	
30.7	5.4	Hy
31.7	5.4	Pt
31.8	5.3	M
32.7	5.4	Su
32.8	4.5	Mu
36.7	5.4	Pt
37.7	5.5	
37.7	5.1	Su
38.7	5.4	Pt
38.8	5.0	M
39.8	5.3	Pt
40.7	5.1	

184208
S Scuti

2133.7	6.7	Mu

184300
Nova Aquilae

2071.5	6.5	Ja
83.5	6.6	
84.5	6.2	Lt

Nova Aquilae

J.D. 242	Est.	Obs.
2084.9	6.4	Pt
94.5	6.3	Lt
97.5	6.3	
98.4	6.3	
99.4	6.3	
2100.	6.6	Pe
01.	6.6	
01.5	6.7	Ja
01.6	6.4	Lt
02.6	6.3	
02.7	6.4	Ro
03.7	6.5	Pt
04.8	6.4	
05.5	6.4	Lt
05.9	6.5	Pt
06.7	6.5	
07.	6.6	Pe
07.5	6.6	Ja
07.6	6.4	Lt
07.8	6.4	Pt
08.9	6.5	
09.5	6.6	Ja
09.8	6.5	Pt
10.7	6.4	
11.	6.6	Pe
15.8	6.4	Pt
16.7	6.5	Ro
16.8	6.5	Pt
19.4	6.4	Lt
19.7	6.5	Pt
19.8	6.5	M
21.4	6.4	Lt
21.7	6.6	Ro
26.7	6.4	Pt
27.7	6.4	
28.7	6.5	
29.7	6.5	Ro
31.7	6.5	Pt
31.8	6.6	M
36.7	6.5	Pt
37.7	6.4	
38.8	6.7	M
38.9	6.5	Pt
40.7	6.4	
40.7	6.5	Ro

184748
TU Draconis

2102.	<12.0	Pe

185243
R Lyrae

2099.7	4.2	Mu_2
2110.7	4.2	
15.7	4.2	Mu
29.2	4.2	Mu_2

185634
Z Lyrae

2113.7	11.1	B

185905
V Aquilae

J.D. 242	Est.	Obs.
2133.8	6.8	Mu

190108
R Aquilae

2084.5	8.0	Lt
2105.5	8.8	
09.8	9.3	M_2
29.6	9.6	B

190529a
V Lyrae

2102.6	12.7	Y
08.5	12.3	Ja

190967
U Draconis

2105.8	11.0	M
33.8	10.6	

190926
X Lyrae

2105.8	9.0	M
30.2	9.4	Pi_2
33.8	9.0	M

190925
S Lyrae

2120.7	<12.4	B

191007
W Aquilae

2138.8	12.6	M

191019
R Sagittarii

2131.8	7.3	Pt

191033
RY Sagittarii

2079.7	6.7	Tp
2101.6	6.3	δ
02.7	6.2	
07.6	6.4	

191124
TY Sagittarii

2072.7	<12.0	Tp

191133
—Sagittarii

2079.8	9.6	Tp

191350
TZ Cygni

2102.6	10.3	Y

191637
U Lyrae

2131.6	11.2	Pi
33.8	10.9	M

VARIABLE STAR OBSERVATIONS, May and June, 1919—Continued

192745
AF Cygni

J.D.	Est.	Obs.
242		
2068.5	7.2	Lt
84.4	7.3	
2100.4	7.5	

192928
TY Cygni

2108.5	<12.0	Ja

193311
RT Aquilae

2131.7	13.3	B

193449
R Cygni

2084.4	12.6	Lt
2104.8	<12.4	M
39.8	<12.4	

193732
TT Cygni

2103.7	8.2	Pt
19.8	8.4	M
28.7	8.1	Pt
29.7	7.6	Hy_2
43.6	8.0	Hu

194048
RT Cygni

2084.4	9.2	Lt
2103.7	8.2	Pt
04.8	8.0	M
16.7	7.0	Pt
19.8	7.5	M
21.4	7.3	Lt
31.6	7.0	Pi
38.7	7.3	V
43.6	7.0	Hu

194348
TU Cygni

2084.4	12.8	Lt
2104.8	11.0	M
19.8	10.5	
31.6	9.8	Pi
38.7	9.1	V
43.6	8.9	Hu

194632
χ Cygni

2068.5	8.8	Lt
77.4	7.1	
84.4	6.5	
84.9	7.0	Pt
86.5	6.8	Ja
92.4	5.8	Lt
2100.	6.2	Pe
01.	6.2	
01.5	6.0	Ja
02.	6.2	Pe
03.7	6.5	Pt
04.8	6.2	M

χ Cygni

J.D.	Est.	Obs.
242		
2105.4	6.3	Lt
07.	6.1	Pe
07.5	6.2	Ja
08.	6.3	Pe
08.9	6.5	Pt
09.5	6.3	Ja
11.	6.5	Pe
15.8	6.3	Pt
16.	6.7	Pe
19.4	6.8	Lt
19.8	6.6	M
21.4	6.9	Lt
22.7	6.4	B
24.7	6.7	
27.7	6.5	Hy
28.6	6.6	B
28.7	6.6	Hy
30.7	6.4	
31.6	7.2	Pi
34.7	6.9	Mu
37.7	7.5	Pt
38.7	7.0	V
40.6	7.3	B
43.6	7.5	Hu

194604
X Aquilae

2097.5	10.6	Lt
2104.8	10.3	M
19.8	11.1	
40.6	12.7	B
43.6	11.9	Hu

194659
S Pavonis

2079.6	9.9	Tp

195116
S Sagittae

2111.7	5.5	Mu
18.8	5.6	Mu_4
29.4	5.6	Mu_5
40.8	6.0	Mu

195202
RR Aquilae

2131.7	12.1	B

195308
RS Aquilae

2121.7	12.1	B

195849
Z Cygni

2085.4	12.7	Lt
2104.8	12.0	M
19.8	11.1	
28.6	10.7	Pi_2
40.7	9.7	Pt

200212
SY Aquilae

242		
2140.6	11.9	B

200357
S Cygni

2097.4	13.7	Lt
2119.8	<12.2	M

200647
SV Cygni

2113.8	9.2	M
29.0	9.5	Hy_3
33.7	9.1	Mu
43.6	8.9	Hu

200747
RX Cygni

2133.7	7.8	Mu

200715a
S Aquilae

2109.8	11.6	M_2
34.7	10.2	Mu
40.6	9.4	B

200715b
RW Aquilae

2109.8	8.8	M_2
34.7	9.3	Mu
40.6	9.1	B

200812
RU Aquilae

2140.6	10.0	B

200938
RS Cygni

2104.8	7.5	M
09.8	8.8	Pt
13.8	7.3	M
31.7	8.5	Pt
33.7	7.5	Mu

200916
R Sagittae

2109.8	8.8	M_2
40.7	9.5	B

200906
Z Aquilae

2102.6	10.4	Lt
31.7	9.4	B
36.8	9.5	M

201008
R Delphini

2109.8	8.2	Pt
31.7	8.7	
33.8	9.6	M

201130
SX Cygni

2119.8	<12.2	M

201121
RT Capricorni

242		
2131.8	7.7	Pt

201647
U Cygni

2084.5	8.6	Lt
2112.3	7.4	M_2
31.7	8.0	Pt
33.7	6.8	Mu

202539
RW Cygni

2104.8	9.2	M
13.8	9.0	
29.0	8.3	Hy_3

202817
Z Delphini

2132.8	10.3	M

202954
ST Cygni

2104.8	11.6	M
22.7	10.0	B
25.8	10.5	M
31.6	10.1	Pi

202946
SZ Cygni

2104.8	9.6	M
24.7	8.7	B
27.8	9.8	M

203226
V Vulpeculae

2105.8	8.8	M
05.9	9.0	Pt
19.8	9.0	M
31.8	8.8	Pt

203611
Y Delphini

2138.8	11.2	M

203847
V Cygni

2068.5	10.2	Lt
2104.8	9.6	M
05.4	10.3	Lt
19.8	10.2	M
22.7	9.0	B

203816
S Delphini

2097.5	9.8	Lt
2105.8	11.3	M
16.8	10.4	
38.7	11.3	V
40.7	11.0	B

203905
Y Aquarii

2116.8	9.8	M

204016
T Delphini

J.D.	Est.	Obs.
242		
2084.9	9.9	Pt
2105.8	9.7	M
16.8	11.0	
40.7	12.2	B

204104
W Aquarii

2116.8	9.2	M

204318
V Delphini

2116.8	<12.5	M

204405
T Aquarii

2116.8	9.6	M

204846
RZ Cygni

2116.8	10.4	M

205030a
UX Cygni

2116.8	11.5	M

205017
X Delphini

2140.7	8.7	B

205923
R Vulpeculae

2084.5	8.4	Lt
84.9	8.6	Pt
2105.5	9.3	Lt
05.8	9.4	M
19.8	10.8	
21.5	10.1	Lt

210129
TW Cygni

2139.8	<11.5	M

210116
RS Capric.

2131.8	8.5	Pt

210382
X Cephei

2136.8	<12.3	M

210504
RS Aquarii

2139.8	10.8	M

210868
T Cephei

2084.4	7.8	Lt
2105.9	8.2	Pt
16.8	8.6	
36.8	9.1	M

210903
RR Aquarii

2136.8	<11.4	M

VARIABLE STAR OBSERVATIONS, May and June, 1919—Continued.

211614
X Pegasi

J.D.	Est.	Obs.
242		
2138.8	9.8	M

213244
W Cygni

J.D.	Est.	Obs.
2087.4	6.3	Lt
97.5	6.3	
2101.	5.9	Pe
05.5	6.4	Lt

213678
S Cephei

J.D.	Est.	Obs.
2097.4	11.7	Lt
2136.8	11.8	M

213753
RU Cygni

J.D.	Est.	Obs.
2109.8	9.0	M_2
22.6	9.3	Pi
31.6	9.8	

213843
SS Cygni

J.D.	Est.	Obs.
2068.5	11.9	Lt
77.4	8.4	
84.4	8.8	
84.9	8.7	Pt
87.4	9.7	Lt
92.4	10.2	
93.4	11.1	
94.4	11.2	
95.4	11.3	

SS Cygni

J.D.	Est.	Obs.
242		
2097.5	11.4	Lt
99.4	11.9	
2101.	11.1	Pe
02.4	11.8	Lt
04.8	11.5	M
05.4	11.9	Lt
05.8	11.6	M
07.	11.9	Pe
07.5	11.2	Ja
09.5	11.0	
09.7	11.6	B
13.7	11.6	
13.8	11.6	M
16.8	11.4	
19.8	11.5	
20.7	11.7	B
21.5	12.0	Lt
22.6	< 11.3	Pi
22.7	11.4	B
24.6	11.4	
24.8	11.3	M
25.6	11.6	Pi
25.7	11.3	B
25.7	11.3	M
26.6	11.5	Pi
27.6	11.2	B
27.8	11.0	M
28.6	9.8	B
28.7	10.2	Pi
28.8	10.1	Hy

SS Cygni

J.D.	Est.	Obs.
242		
2128.9	9.8	Hy
29.6	9.3	B
29.7	9.4	Pi
30.8	9.3	Hy
31.6	9.0	B
31.6	8.5	Pi
31.7	8.9	Pt
31.8	8.5	M
32.6	8.8	B
32.6	8.3	Pi
32.7	8.9	Mu
32.8	8.7	M
33.8	8.6	
34.6	8.3	Pi
36.7	9.1	Mu
36.8	9.1	M
38.7	9.8	V
38.8	9.7	M
39.6	10.0	Hu
39.8	10.1	M
40.6	9.8	B
40.7	9.8	Mu
40.8	10.5	M
43.6	10.6	Hu

213937
RV Cygni

J.D.	Est.	Obs.
2105.9	8.0	Pt
09.8	8.1	M_2
16.8	8.0	Pt
22.6	8.1	Pi

RV Cygni

J.D.	Est.	Obs.
242		
2131.6	8.1	Pi
33.7	6.5?	Mu

214024
RR Pegasi

J.D.	Est.	Obs.
2138.8	13.1	M

215605
V Pegasi

J.D.	Est.	Obs.
2140.8	8.6	M

215934
RT Pegasi

J.D.	Est.	Obs.
2138.8	10.6	M

220412
T Pegasi

J.D.	Est.	Obs.
2138.8	9.1	M

220613
Y Pegasi

J.D.	Est.	Obs.
2138.8	10.7	M

220714
RS Pegasi

J.D.	Est.	Obs.
2138.8	11.0	M

222439
S Lacertae

J.D.	Est.	Obs.
2102.5	12.9	Lt
40.8	11.6	M

223841
R Lacertae

J.D.	Est.	Obs.
242		
2102.5	10.7	Lt
40.8	< 12.3	M

225914
RW Pegasi

J.D.	Est.	Obs.
2116.8	9.7	M

230110
R Pegasi

J.D.	Est.	Obs.
2116.8	11.3	M

230759
V Cassiop.

J.D.	Est.	Obs.
2097.5	11.2	Lt
2116.8	9.4	M

231425
W Pegasi

J.D.	Est.	Obs.
2116.8	9.2	M

233335
ST Androm.

J.D.	Est.	Obs.
2116.8	9.6	M

233451
SV Cassiop.

J.D.	Est.	Obs.
2102.6	8.2	Lt

235350
R Cassiop.

J.D.	Est.	Obs.
2097.5	6.7	Lt
2136.8	7.4	M

235525
Z Pegasi

J.D.	Est.	Obs.
2116.8	10.0	M

No. of Observations: 1070. No. of Stars Observed: 244. No. of Observers: 20.

COMMUNICATIONS.

A Planet Which Did Not Exist.—As we all know very well, little Mercury is the nearest of the eight planets to our Sun. Possibly there may be some tiny planetary body between Mercury and the Sun, but that is improbable. Nevertheless, at one time, it was believed that such a planetary body had been discovered, for, on March 26, 1859, Dr. Lescarbault at Orgeres in France announced that he had beheld a small planet cross the Sun's surface, between Mercury and the Sun. The famous astronomer Leverrier visited Dr. Lescarbault, and was convinced that the Doctor had not been deceived. This new addition to the eight other planets of our Solar System was named Vulcan, and although other astronomers believed afterwards that they saw Vulcan, it is certain today that this alleged planet never existed. Not only was it given a name but also its

distance from the Sun was estimated to be 13,000,000 miles and its diameter 2,500 miles. Since Dr. Lescarbault's "discovery" of Vulcan, about 60 years have passed, telescopes and telescopic cameras have been vastly improved, but no planet between Mercury and our Sun has been observed. That tiny particles of matter exist on orbits between our Sun and Mercury astronomers do not doubt, indeed larger particles may exist there; but after all the long and careful search of our Sun's surface and environments, with modern telescopes and methods, it seems impossible that any body deserving the name of planet is revolving between the Sun and the orbit of Mercury. CHARLES NEVERS HOLMES.

Newton, Mass.

A Very Bright Meteor.—On Friday, June 13, at 7:15 p. m., while the sun was still shining brightly, a number of people in this city saw a bright meteor passing from nearly east to west. The passage of the meteor was followed by a most terrific explosion, which took place about five or ten minutes after the meteor passed. I was on my front porch, when my little boy called out to me that there was a bright star going over. I immediately pulled out my watch and it was exactly 7:15, daylight saving time. I was very much surprised on reading the Baltimore papers, the next day, to see that the people at Catonsville, near Baltimore, had seen a meteor at exactly the same time.

A very reliable man, who lives at Golden Hill, about fifteen miles from Cambridge, told me that he saw the meteor when it exploded. He said that it was a little west of him at the time of the explosion. The cloud of smoke was exactly like the smoke from a gun, except that it was very dense and had a hole in the middle, thus forming a ring. The wind was west at the time and the smoke cloud drifted directly over his head in about an hour, so that it could not have been very far from him at the time of the explosion. He described the explosion as being the most terrific that he had ever heard, as everything in nature seemed to shake and tremble in a manner that he had never seen before, although he is a man who has been around where heavy cannon have been fired and has been within a few hundred yards of the largest cannon in the American Navy when they were being fired.

A colored man who was standing on Slaughter Creek Bridge, which is not very far from the place where the gentlemen above mentioned was at the time of the explosion, declared that he saw particles of the meteor fall into the water at that point. This meteor was seen by the people of Easton and Oxford, Maryland, approximately at the same time it was seen in Cambridge, Easton, Oxford and Slaughter Creek, being practically in a straight line, almost east and west. If it was the same meteor which the people of Catonsville saw, it must have changed its course very considerably, as Catonsville would be nearer northwest from Easton and Cambridge. I presume you will hear something more about this meteor from someone in Baltimore or the vicinity. There was another meteor which passed here, just as bright as this, in February of the present year. This was very bright and those who saw it declare that it lighted things up as light as if it were day. J. WATSON THOMPSON.

Cambridge, Maryland, June 19, 1919.

Results of Meteoric Observations for 1916-18.—During the years 1916-18 meteoric astronomy made a great stride toward perfection in this country, but owing to the war it has declined. We hope to see it advance once more. Since 1911 valuable data have been gathered on the subject by the American Meteor

Society, which was organized in that year. Few observers of meteors have published their data. It was sent to the president of the American Meteor Society, Mr. Charles P. Olivier.

For three years I have gathered data which might be of interest to other observers for the purpose of comparison and to some who could use such data.

The average number of meteors for the month and night are:

Month	Night	Month	Night	Month	Night	Month	Night
Jan. 35	13.2	April 102.6	22	July 131.3	32.8	Oct. 163	32.6
Feb. 86.6	13.6	May 141.6	26.5	Aug. 270.3	47.6	Nov. 133	26.6
Mar. 88	13.9	June 142.3	35.5	Sept. 213	42.6	Dec 27	27

The average was one meteor every 5.5 minutes.

The average for each hour was 11.9 meteors.

The total number of hours and minutes spent were 385 hours 48 minutes. 4097 observations were made.

It will be noticed that in December of the year the lowest number were seen and in August the highest number were seen. This was mainly because in the winter months conditions are very unfavorable for good work. Meteors seem to be very scarce in the winter months especially in December, even if the Geminids are due at that time. In the summer and fall months the meteors are very numerous. It is in these months that the greatest number of showers take place and the best results are obtained.

The data gathered for magnitudes and colors for 1917-18 follow:

		>0	0	1	2	3	4	5
Magnitudes	1917	87	42	90	145	198	233	279
	1918	20	14	33	66	63	67	76

		W	B	R	G	Y	O	V
Colors	1917	571	354	124	13	12	0	0
	1918	174	125	39	0	0	0	1

It will be noticed in the table of magnitudes that in 1918 nearly the same number of meteors of magnitudes from 2-5 were observed. This was probably due to changing atmospheric conditions around here caused by the forming of Lake Wisota. The power company put in a dam which backed up many miles of water. This caused fogs and an atmosphere saturated with water vapor which made observing more difficult. The colors show a decrease in number of meteors from green to violet. If anybody can use these data they are entirely welcome to them. Mr. Charles P. Olivier, president of the American Meteor Society, has the maps that these data are taken from and he has worked up part of the meteoric radiants and other results of greater value.

JOHN KOEP.

Chippewa Falls, Wis.

GENERAL NOTES.

The next issue of POPULAR ASTRONOMY, the October number, will appear on September 25.

Mr. Latimer J. Wilson, who for the last few years has been engaged in telescopic photography for the Eastman Kodak Company at Rochester, N. Y., will return to Nashville, Tenn., in the fall to continue observations of Mars in collaboration with Professor Pickering's associated observers.

American Academy of Arts and Sciences.—At the May meeting of the American Academy of Arts and Sciences, Professors Joseph Lipka, G. A. Miller, F. R. Moulton and Virgil Snyder were elected fellows in the Section of Mathematics and Astronomy.—(*Science*, July 18, 1919.)

Dr. George Ellery Hale, director of the Mount Wilson Observatory and foreign secretary of the National Academy of Sciences, who has been for the past ten years a correspondent of the Paris Academy of Sciences, has been elected a foreign associate, taking the place of Adolph von Baeyer, declared vacant by the academy. The foreign associates are limited to twelve, and the distinction has been held by only two Americans—Simon Newcomb and Alexander Agassiz. The National Research Council upon the presentation and acceptance of Dr. Hale's resignation as its chairman and the election of Dr. James R. Angell as his successor, "created and bestowed in perpetuity upon Dr. Hale the title of honorary chairman in recognition of his services to the National Research Council and to science and research by indefatigable efforts that have contributed so largely to the organization of science for the assistance of the government during the war, and the agumentation of the resources of the United States through the newly intensive cultivation of research in the reconstruction and peace periods that follow."—(*Science*, July 4, 1919.)

Solar Eclipse of May 28-29.—Additional information regarding the observations made by Dr. Bauer's party at Cape Palmas, Liberia, during the total solar eclipse of May 28-29, states that the magnetic effect observed in previous eclipses has been confirmed. The inner corona was very bright, and marked outer corona extensions south southeast and north northwest were observed. No shadow bands were seen.—(*Science*, July 4, 1919.)

A Solar Observatory for New Zealand.—From "The Observatory" for June, 1919, we note that the plan for establishing a solar observatory near Nelson, New Zealand, interrupted by the death of Mr. Cawthron, may yet be realized. Professor Hale of the Mount Wilson Observatory will prepare a plan for suitable instruments which would be inexpensive but which would enable observations to be made which would be of value.

International Astronomical Union.—A delegation of American astronomers, headed by Professor W. W. Campbell, Director of the Lick Observatory, is now in attendance at a meeting in Brussels called for the purpose of organizing the International Astronomical Union. This new organization will take over and carry forward the work hitherto in the hands of the committee of the Carte du Ciel, the International Union for Co-operation in Solar Research, The Central Bureau for the exchange of Meteorological Telegrams, and other astronomical organizations. Sections of this Union will be organized in the several countries. The American section includes one or more representatives from each of the following organizations: the National Academy of Science, The American Astronomical Society, the American Mathematical Society, the American Physical Society, the Naval Observatory, and the Coast and Geodetic Survey. The American delegates at a preliminary meeting held in Washington June 23-24 took up tentative suggestions regarding the reform of the calendar, and other matters to be presented at the meeting in Brussels.

The Bulletin Astronomique, according to a communication received from the director of the Observatory of Paris will be changed in name to *"Revue Générale des Travaux Astronomiques."* The new journal will be published monthly in the French language and will contain brief abstracts of research relative to astronomy and geodesy. Astronomers are asked to send to the new publication brief reviews of papers for publication.

Satellites of Mars in "Gulliver's Travels."—Attention is called by Mr. H. Jeffries of Wilts, England, to the following passage in "Gulliver's Travels": "They have likewise discovered two lesser stars, or satellites, which revolve about Mars, whereof the innermost is distant from the centre of the primary planet exactly three of his diameters, and the outermost five; the former revolves in the space of ten hours, and the latter in twenty-one and a half; so that the squares of their periodical times are very near in the same proportion with the cubes of their distance from the centre of Mars, which evidently shows them to be governed by the same law of gravitation that influences the other heavenly bodies." While the above description does not exactly accord with the facts of the satellites of Mars now known, it is interesting to note that as a matter of fiction it is remarkably near the truth. "Gulliver's Travels" was written about a hundred years before the discovery of the satellites of Mars by Asaph Hall in 1877.

Solar Halos Observed at Tee Harbor, Alaska.—An unusually striking formation of solar halos occurred at Tee Harbor, Alaska, on June 9, 1919. A report of these halos has been sent by Mr. W. E. Freeman. The halos occurred at about eight o'clock in the evening while the sky was almost clear. They consisted of two concentric circles, the sun being at the centre. At the highest point of the inner circle, two brilliant arches that appeared like wings extended symmetrically to the north and to the south. Tangent to the outer circle at its highest point was an inverted arc showing very distinctly the colors of the rainbow. The two points on opposite sides of the sun, usually referred to as "sun-dogs" were unusually brilliant, so much so, according to the report, that some people could hardly distinguish which was the real sun.

An interesting feature of this display for the people at Tee Harbor was the fact that when observed from this point it appeared exactly over the place where the steamship Princess Sophia went down last fall.

The Twenty-Third Meeting of the American Astronomical Society.—The following information, taken from the notice of the meeting issued June 15, will be of interest to all who are planning to attend.

GENERAL

On the invitation of Professor W. J. Hussey, the Twenty-Third Meeting of the American Astronomical Society will be held at the Detroit Observatory, University of Michigan, Ann Arbor, from Tuesday, September 2, to Friday, September 5, 1919. The Helen Newberry Residence will be open for the accommodation of attending members. Special provisions will be made for ladies and married couples, but it is desirable that early arrangements be made for such special provision. Members expecting to attend the meeting are urgently requested to send in their names by August 28 in order that suitable accommodations may be provided for them. The rates for rooms in Newberry Residence will be $1.00 per day per person. Meals will be furnished at the Michigan Union at reasonable rates.

Ann Arbor is on the main line of the Michigan Central Railroad from Detroit to Chicago. It is also on the main line of the Ann Arbor Railroad from Toledo.

The Helen Newberry Residence and the Michigan Union are situated on State Street, opposite the University. Street cars from near the railway stations pass these buildings.

The American Mathematical Society and the Mathematical Association of America will hold meetings in Ann Arbor during the same week, and arrangements will be made for a joint meeting and a dinner with these societies.

There will be no occasion in connection with the meeting on which formal dress will be necessary.

COMMUNICATIONS

Titles of papers which are received by the acting secretary at Ann Arbor by August 22 will be placed on the printed program, subject to the approval of the Council. When two or more papers are offered by the same member, only one of these will be assigned a place on the regular program, while the others will be placed on a supplementary program to be called for if time permits. Abstracts of papers read only by title will be included as heretofore in the printed report.

Members are urged to send in titles and abstracts as promptly as possible. At the last meeting of the Society about half of the titles were received too late to be printed on the regular program, distributed a week before the meeting.

PRESENTATION OF PAPERS

The Council requests members to bear the following points in mind when preparing papers. When the author of a paper is not present at a meeting, his communication should be adapted to oral presentation; certain details, although indispensable for complete publication, should not be read in extenso. It is also suggested that even when presenting our own papers most of us are more interesting when we are speaking poorly than when we are reading well. The great advantage of a scientific meeting is to bring out informal discussion and exchange of views, leaving the study of difficult or technical details to the convenience of those particularly interested.

NEW MEMBERS

Nominations to membership will be acted upon by the Council at its first meeting, and later during the sessions. Prospective members and others interested are always welcome at the meetings of the Society.

NOMINATION OF OFFICERS

The attention of the members is called to the proposed changes in the Constitution in regard to the election of officers. The enclosed report of the special committee has the unanimous endorsement of Council, and the vote on the amendments will be taken at the Ann Arbor Meeting. Members may send in nominations as heretofore and these ballots will be used for the information of the proposed nominating committee; but in case the amendments to the Constitution should fail of adoption, the ballots will be counted as regular nominations.

Officers who continue to serve unexpired terms are E. W. Brown and Otto Klotz, and the secretary. Nominations are therefore in order for president, two vice-presidents, treasurer and *four* councilors.

SECRETARY FOR THE ANN ARBOR MEETING

Because of the absence of the regular secretary from the country until late in August, Professor R. H. Curtiss has kindly undertaken to perform the secretary's duties preceding the meeting. All communications, nominating ballots, etc., should be sent to him at Ann Arbor.

Following is the preliminary program of the meeting:

PROGRAM

Monday, September 1, 1919

8 P. M. Meetings of the Council at the Detroit Observatory.

Tuesday, September 2

10 A. M. Opening Session, Natural Science Hall.

2 P. M. Session for papers.

8 P. M. Reception at Detroit Observatory.

Wednesday, September 3

9 A. M. Meeting of the Council.

10 A. M. Session for papers.

2-4 P. M. Session for papers.

4-6 P. M. Inspection of University buildings.

8 P. M. Conversazione—Exhibits of work. Reports from Brussels conference, etc.

Thursday, September 4

9 A. M. Meeting of the Council.
10 A. M. Session for papers.
2 P. M. Joint meeting with American Mathematical Society, and Mathematical Association of America.
7 P. M. Joint dinner with mathematical societies.

Friday, September 5

9 A. M. Meeting of the Council.
10 A. M. Session for papers. Election of officers.

The Metric System.—The World Trade Club of San Francisco is conducting a vigorous campaign for adoption of the units of the metric system of weights and measures.

They show a striking anomaly: That the metric system was invented by a Briton, James Watt, in 1783, and yet all civilized nations have adopted it exclusively, excepting the United States and Great Britain.

That the so-called "British system" of weights and measures is of German origin—a relic of the old German Hanseatic trade league—and yet Germany scrapt it in 1871 and adopted the metric system, invented by a Briton.

People of Britannia and America may well ask themselves whether they are not carrying conservatism too far.

The Metric System is no untried theory.

Its principle—the principle of decimal computation—has been used in the monetary system of the United States since 1786. If the United States had heeded Thomas Jefferson, we should also have adopted this system of weights and measures based on decimals—so simple a system that a child can learn its main features in ten minutes. We know how well it works with money. It will work equally well with weights and measures.

The World Trade Club has started the ball rolling. What we all need is to look the subject up.

Orbits of three Spectroscopic Binaries.—In the *Astrophysical Journal* for April 1919 are given the orbits of three spectroscopic binary stars determined by Walter S. Adams and Alfred H. Joy. For two of these stars the spectra of both components could be measured and the orbits have also been determined from photometric observations, so that it is possible to compute with considerable accuracy the actual dimensions, masses and densities of the component stars as compared with our sun. The stars are: the brighter component of the double star 30 *Arietis*, Σ5; the variable star W *Ursae Majoris*; and the variable star Z *Herculis*. Their positions for 1900.0 are:

	α	δ
	h m	° ′
30 Arietis (Σ5) = Boss 592 and 593	2 31.2	+24 13
W Ursae Majoris	9 36.7	+56 25
Z Herculis	17 53.6	+15 09

For Boss 593 the elements found for the orbit are:

Period	$P = 9.851$ days
Velocity of the system	$\gamma = +14.42$ km
Semi-velocity range of primary	$K = 22.48$ km
Angle of major axis from line of nodes	$\omega = 129°.6$
Eccentricity of orbit	$e = 0.1455$
Epoch of Periastron Passage	$T =$ J. D. 2421586.899
Projected semimajor axis	$a \sin i = 3{,}012{,}700$ km
Minimum mass	$\frac{m_1^3 \sin^3 i}{(m+m)} = 0.0113\ \odot$

For W *Ursae Majoris* the following results are obtained:

Period (Shapley and Van der Bilt)	$P = 0.3336392$ day
Eccentricity (assumed)	$e = 0.00$
Velocity of center of mass	$\gamma = -5$ km
Semi-velocity range of primary	$K_1 = 134$ km
Semi-velocity range of secondary	$K_2 = 188$ km
Radius of orbit of primary	$a_1 \sin i = 610{,}000$ km
Radius of orbit of secondary	$a_2 \sin i = 860{,}000$ km
Mass of primary	$m_1 \sin^3 i = 0.67 \odot$
Mass of secondary	$m_2 \sin^3 i = 0.48 \odot$

With the aid of other data obtained from Russell's photometric orbit the absolute dimensions, masses and densities are found as follows, the two stars being equal ellipsoids:

Radius of the primary orbit	$= 620{,}000$ km
Radius of the secondary orbit	$= 880{,}000$ km
Radius of the relative orbit	$= 1{,}500{,}000$ km
Greatest semi-axis of each star	$= 548{,}000$ km $= 0.78$ sun's radius
Intermediate semi-axis of each star	$= 408{,}000$ km $= 0.58$ sun's radius
Polar semi-axis of each star	$= 373{,}000$ km $= 0.54$ sun's radius
Mass of primary	$= 0.69 \odot$
Mass of secondary	$= 0.49 \odot$
Density of primary	$= 2.8 \odot$
Density of secondary	$= 1.9 \odot$

The densities are remarkable as being the highest known in any stellar system.

Z *Herculis* is a variable star of the Algol type with a period of about four days. The elements of the orbit come out:

Photometric period (Lehnert)	$P = 3.992775$ days
Eccentricity (assumed)	$e = 0.00$
Velocity of center of mass	$\gamma = -46.5$ km
Semi-velocity range of primary	$K_1 = 88.2$ km
Semi-velocity range of secondary	$K_2 = 101.8$ km
Radius of primary orbit	$a_1 \sin i = 4{,}800{,}000$ km
Radius of secondary orbit	$a_2 \sin i = 5{,}600{,}000$ km
Mass of primary	$m_1 \sin^3 i = 1.5 \odot$
Mass of secondary	$m_2 \sin^3 i = 1.3 \odot$

Two solutions are given for the absolute dimensions of this system, the one on the supposition that the star discs are uniformly luminous, the other assuming that the discs are darkened toward the edges by atmospheric absorption. The two solutions give nearly the same results.

	"Uniform" Solution	"Darkened" Solution
Inclination of orbit	83° 40′	82° 00′
Radius of primary orbit	4,870,000 km	4,880,000 km
Radius of secondary orbit	5,620,000 km	5,640,000 km
Radius of relative orbit	10,490,000 km	10,520,000 km
Radius of bright primary star	1,020.000 km	1,230,000 km
Radius of faint secondary star	2,170,000 km	2,290,000 km
Mass of primary	1.5 ⊙	1.6 ⊙
Mass of secondary	1.3 ⊙	1.3 ⊙
Density of primary	0.5 ⊙	0.3 ⊙
Density of secondary	0.05 ⊙	0.04 ⊙

It will be noticed here that the secondary star is much larger than the primary but less dense.

Orbits of Spectroscopic Binary Stars.—Volume III, Nos. 10, 11 and 12 of the Publications of the Dominion Observatory, Ottawa, Canada, contains determinations of the orbits of three spectroscopic binary stars: Boss 6142, Boss 2484 and 125 Tauri. The elements are as follows:

Star	Boss 6142	Boss 2484	125 Tauri
Computer	R. K. Young	W. E. Harper	J. B. Cannon
Period	13.435 days	15.986 days	27,864 days
T	J. D. 2,420,800.634	2,419,408,027	2,420,471.607
e	0.105	0.504	0.55
ω	339°.56	355°.2	335°
K	115.5 km	63.34 km	25.5 km
γ	− 26.7 km	− 13.11 km	14.8 km
$a \sin i$	21,200,000 km	12,026,000 km	8,160,000 km
$a_1 \sin i$	30,700,000 km	13.981,000 km	

In the case of Boss 6142 the H and K lines do not shift with the others. The mass ratio $\frac{m_1^3 \sin^3 i}{(m+m_1)^2}$ comes out 2.11 ⊙.

For Boss 2484 the masses of the two components come out $m \sin^3 i = 1.48$ ⊙ and $m_1 \sin^3 i = 1.27$ ⊙.